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PRESIDENT'S MESSAGE

The Year in Retrospect

By E. L. Slagle

President, American Institute of Industrial Engineers

Since this is my last message as President, a report summarizing the year's activities seems in order. Due to Journal limitations a detailed report is impractical. A brief report does have one advantage: more people read it. Eventually the AIIE will have a comprehensive annual report issued as a separate publication—this is normal practice for such engineering groups as ours. Such a report will be possible once we have a full-time executive secretary to relieve the President of many burdens currently diverting attention from more important matters.

For the purposes of this report, a committee-by-committee approach is not utilized since it would not provide the continuity and clarity to be achieved by grouping various items of interest in the following manner:

A. Improving industrial engineering service.
B. Assistance to chapters and membership.
C. Actions to strengthen the AIIE.
D. General.

Improving Industrial Engineering Service

The primary purpose of the AIIE is to improve industrial engineering services available to the public—a thought to keep uppermost in our minds when difficulties arise over relatively unimportant matters. We must recognize this purpose and take actions designed to improve and render more useful the tools and techniques of industrial engineering and to continually seek new applications of industrial engineering methods and approaches. During the last year, our efforts in this direction embraced the following three activities:

1. *Research*

The policies, procedures, and organizational arrangements necessary to implement a research program as outlined in the November-December, 1955, issue of the Journal have been adopted. A portion of the funds made available by the recent dues and fees increase has been earmarked for the research budget. By providing incentives through assistance and recognition we hope to increase and coordinate creative thinking being applied to the field of industrial engineering. We believe that activity in the area of research will gain considerable momentum in the space of a few short years.

2. *Long Range Planning*

Early in 1955, it became apparent that our more substantial problems no longer involved physical growth as such. The size of our organization, and certain developments in our relationships with other national organizations, clearly indicated that we must take definite steps to assume the responsibilities inherent to a group such as ours. Don Malcolm, then National President of the AIIE, called a meeting of the leaders in the industrial engineering field for the purpose of reviewing our activities and discussing the proper approach to achieve the objectives of the AIIE. You may recall reports of two separate

meetings of this group (now referred to as the Special Advisory Committee). To provide for the proper utilization of the work of this committee, and to provide for continual review of our various programs, our Long Range Planning Committee was established in June of 1955. Simultaneously, our Finance Committee was established. This latter committee was established to work with the Long Range Planning group, and to advise the President with regard to both long range and short range financial needs as well as financial plans.

3. *Engineering Manpower*

The shortage of engineers, together with the reasons for this situation, does not need to be enlarged upon here. Many of our conference programs are designed to help with this problem, and many of our members take active part in vocational guidance counsel for secondary school students. In an effort to assist the chapters and members interested in supplying our country with more and better engineers, and to help the many universities which have requested some type of handout information concerning industrial engineering for use with students, the Executive Committee assigned to the Director of Public Relations the task of assembling a brochure. This brochure, entitled Opportunity Unlimited in Industrial Engineering, was published by national headquarters in March, 1956, and is already in widespread use.

Assistance to Chapters and Membership

1. *Improved Journal*

Our Journal has been improved considerably in recent months. Ultimately, we must have a Journal comparable in quality with those published by other professional engineering organizations. Definite plans have been made for the next improvement. These plans will be placed into effect in late 1956 or early 1957 by utilizing some of the funds made available as a result of the recent increase in dues and fees.

2. *Membership Kits*

Our Director of Membership has completed work on a membership kit designed to facilitate the work of chapter membership committees. The kit, developed in response to many demands for such assistance, has been mailed to the chapters, officers, directors, and national committee chairmen. There is reason to believe that the membership kit will increase our already rapid growth rate.

3. *Travel by National Officers*

We are all acutely aware of the need for improved communications. There is an increasing demand by the chapters for visits by national officers for the purpose of discussing particular problems or for the purpose of obtaining first-hand information with regard to the activities and problems of the AIIE. This situation has been recognized for quite some time, but a solution required financial assistance to the officers involved in such travel. During 1955, and in 1956 to date, the number of officer visits to chapters has increased considerably with very little financial help from the national organization. Some of our officers have been able to take the necessary time away from their jobs, and, through use of their own funds or through the generosity of their companies (or organizations), have made a substantial contribution to better communications. Here again, funds which will be available through the recent dues and fees increase are earmarked for improved service.

4. *National Meetings*

In response to many requests for assistance, both in the form of financing and guidance, the position of Director of National Meetings was established. It is the current responsibility of this director to establish the necessary policy and procedure guides for use by the national and the chapters. Current efforts are directed only at national meetings—normally those involving national or regional conventions. Eventually, however, policy and procedure guides will also have to be established in connection with local conferences. The quantity of such conferences will lead us into a quality problem and the prestige of the AIIE will become involved.

5. *Special Surveys*

Many requests are received in connection with such matters as the progress of industrial engineers following graduation, a comparison of industrial engineering salaries with the salaries of other branches of engineering, the rate of progress of industrial engineers as compared with other engineers, etc. During the year a Special Survey Committee was established. This committee is currently developing a questionnaire designed to obtain answers to some of these questions.

Actions to Strengthen the AIIE

1. *Executive Secretary*

The decision to employ a full-time Executive Secretary is the most significant forward step taken by the AIIE during the last year. It is of critical importance that we have a full-time Executive Secretary with extensive industrial engineering experience and with a national reputation, to represent us in dealings with other national organizations or in hearings before government committees. It will be necessary for such an individual to make some of the many appearances and speeches before our own or other groups, to handle many of the operational problems currently referred to the President, and to facilitate committee work and communications. We must operate on a basis comparable with that of other such organizations and on a basis consistent with our abilities and requirements—we do have able men and adequate programs, but the demands for service exceed, and will continue to exceed, our ability to perform until we have this full-time Executive Secretary on the job.

Essentially, there were three reasons for this action:

a. It is normal practice for organizations such as ours to have an Executive Secretary.

b. From discussions with other groups it was apparent that our size and growth rate justified this action at this time.

c. Much work that should, and could, be done is being left undone to the detriment of the AIIE and industrial engineering in general. To emphasize this latter statement, I am going to describe briefly what was expected of the writer during the last year.

a. Attend 8 Executive Committee meetings in Columbus, Ohio.

b. Attend 3 Board of Trustees meetings—St. Louis, Columbus, and Washington.

c. Prepare 6 Journal messages.

d. Attend 7 committee meetings in various parts of the United States.

e. Attend 3 meetings called by other professional engineering groups in various parts of the United States.

f. Prepare 7 speeches.

g. Visit 16 chapters.

h. Receive 30 to 40 pieces of mail each day—letters, and reports (sometimes voluminous). Write letters or make phone calls in connection with an average of 15 to 20 letters received each day.

i. Direct the activities of 25 individuals—officers, directors, and committee chairmen.

These demands are no different from the demands made upon the previous President or the current Executive Secretary. Since the positions of President and Executive Secretary are currently supposed to be part-time jobs, and since there is no recompense involved, it is easy to understand why only three out of nine individuals contacted as possible nominees for the office of President this year agreed to run. The AIIE cannot afford the inefficiency which results from this overload, nor can it afford to have capable people refusing to run for office as they did last year as well as this year.

With luck, and with the funds made available from the recent dues and fees increase, we will have a full-time Executive Secretary sometime in 1957. Our problem in this connection will be to find an individual with the necessary qualifications at the salary we can afford to pay. The attempt to locate the proper individual was initiated early this year.

2. *Policy and Procedure Manual*

Many policies and procedures are required, and many policies and procedures already developed can only be located through the thorough search of people's memories, old letter files, and minutes of past meetings. A manual is being prepared at national headquarters which will incorporate policies and procedures already in effect and make provision for future requirements. A considerable amount of work is involved, and we anticipate that it will be quite some time before we have the manual developed to the point where it could be released to the chapters. Certainly such a manual would be of considerable help in the operation of the AIIE in general and in the operation of the chapters specifically.

General

1. *Growth*

The membership growth rate of approximately 90 new members per month (net increase) originally established in 1952, has continued through the year of 1955 and 1956 to date. Chapter growth seems to be proceeding with equal vigor. At the time of this writing (March, 1956) two chapters have been chartered in 1956, five chapters—Wichita, Macon, Albuquerque, Chattanooga, and Oklahoma City—should be granted charters in the very near future. Many other chapters are in earlier stages of development. Six new student chapters have been chartered in less than a year's time.

2. *Chapter Projects*

This year many of the chapters have indicated an interest in a chapter project designed to assist the AIIE on a national scale and, incidentally, provide a focal point of interest for the members of the chapter. This mature, progressive approach to the attainment of our objectives certainly augurs well for the AIIE. The Rochester Chapter, for example, is interested in developing a film portraying the uses of industrial engineering techniques. The Columbus Chapter is investigating the possibility of establishing some national facility to act as an employment clearing house. The St. Louis Chapter is interested in developing a TV program. At this writing both the Washington and New York Chapters are involved in establishing national conferences. It should be pointed out that some chapters have a continuous project. Among these are: the East Tennessee Chapter which works with the Membership Qualifications Committee in processing over 100 applications per month; and the Atlanta Chapter which has long been responsible for the publication of the Journal. Still another type of project activity covers regional and local conferences sponsored by some of our chapters. All of these conferences are indirectly beneficial to all industrial engineers, and some of the conferences are of direct benefit to all members of the AIIE due to joint financial participation between the national and the chapter involved.

To summarize, concrete steps were taken to improve industrial engineering service and to assist both chapters and members. In addition, we have certainly strengthened the AIIE financially and organizationally while maintaining an extremely healthy growth rate.

I want to thank all of you for your cooperation and efforts on behalf of the AIIE. Your attitude, willingness, and initiative have both minimized the number of problems involved, and paved the way to a solution of problems requiring your assistance.

Summary of The Industrial Engineering Symposium, Cornell University, October 1955

Reported by Austin Weston, *Industrial Engineering Division, R. R. Donnelley & Sons Company*

This two-day Symposium was sponsored by the AIIE Long Range Planning Committee to consider some of the important issues facing the Industrial Engineering profession. The 19 participants were drawn from prominent Industrial Engineers in industry, in the academic field, and in the management consulting field. Four topics, summarized below, were developed at length by this group:

1. A Definition of Industrial Engineering
2. The Role of the Professional
3. The Development of Industrial Engineers
4. Industrial Engineering Publicity

A Definition of Industrial Engineering

The group agreed that the first order of business should be to attempt to develop a definition of this profession. All felt that it was extremely important to have such a definition which could be publicized by the American Institute of Industrial Engineers. This definition should reflect the unique character of the Industrial Engineer and also be sufficiently general to include the diverse areas in which Industrial Engineering can be of use.

The definition agreed upon was:

> **"Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of men, materials, and equipment. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems."**

It was recognized that this definition could be modified as the need arose and could also be improved in the future. The American Institute of Industrial Engineers at its October Board of Trustees meeting, accepted this definition for publication in its forthcoming Industrial Engineering Opportunities brochure, and is also having it printed in a form suitable for framing.

The Role of the Professional

The group divided this topic into three areas for discussion: the technician vs. the professional engineer, how to strengthen the professional calibre of Industrial Engineering, and the spirit of a profession.

A. *The Technician vs. the Professional*

Discussions stressed the sizable differences between the professional engineer and the technician. It was agreed that an interim step, trainee professional, is necessary in the transition from purely technical to full-professional activity. Technicians as well as professionals require skills, knowledge, and experience. However, the technician's toolkit restricts itself to more routine type activity which is generally carried out under specific supervision. In contrast, the techniques of the professional are marked by their breadth. His instruments include judgment and decision-making. Their character is primarily creative. Their aim is frequently the integration of his own work with that of associates and subordinates. Professional Industrial Engineering normally requires formal engineering education. The group noted the existence of exceptions to this general requirement. This has been caused by a number of reasons, including the relative youth of the field which made it necessary for many of its practitioners to gain considerable slices of their education in practice.

B. *How to Strengthen the Professional Calibre of Industrial Engineering*

Four major steps were suggested for the practical pursuit of this objective:

(*a*) *Codification of Existing Knowledge:* This aim was brought into somewhat easier reach by agreement, in the previous session, on a definition of Industrial Engineering. Further and continuing research was called for to enlarge the content of that body of knowledge known as Industrial Engineering. This places added emphasis upon better understanding and closer cooperation between the business and the academic world. It also charges the existing professional society in the field, the American Institute of Industrial Engineers, with the responsibility to promote progress in the accomplishment of the steps outlined in this and subsequent paragraphs.

(*b*) *Establishment and Maintenance of Standards:* Criteria must be agreed upon and enforced with regard to a number of vital areas such as curriculum content, type and breadth of practical experience, accreditation, licensing, ethical conduct, etc.

(*c*) *Dissemination of Existing Knowledge and Standards:* In this area the American Institute of Industrial Engineers

should see one of its most immediate fields of action. Steps leading to further improvements in the "JOURNAL OF INDUSTRIAL ENGINEERING" and faithful maintenance of the existing strictness of membership qualifications were unanimously applauded as proper starting points for ever-expanding concern with this block of responsibilities.

(d) The Contribution by Business Management: Companies who benefit from industrial engineering work as well as those who intend to do so, should recognize its potential. The group felt that only in the minority of instances has its full measure been utilized. Much can and should be done through proper public relations activity (see later discussions, Industrial Engineering Publicity). Beyond this, it was stressed that only management can provide within its organization the climate which permits highest possible effectiveness of professional work in as yet non-professional surroundings.

C. *The Spirit of a Profession*

In addition to professional skill, knowledge and experience, a fourth dimension, attitude, was spotlighted by the discussion as a mandatory trait of every professional individual. It should focus on the long range, thus center on preventive measures rather than on fire fighting treatment. Professional attitude is the antithesis of narrow viewpoints which are often engendered by the restrictive tools of a specialist. It demands visualization of all significant relationships within each situation. It militates, itself, against "closed shop" sentiment within a group. Motivation is the mainspring of attitude. Seeking to render service as the prime motivation was pointed out as the overriding objective of any professional endeavor. This need not exclude other motivations, such as economic ones. Yet one of the hallmarks of professional attitude is recognition of the service motive as the supreme target. A profession, the group felt, cannot demand recognition by the public. It must earn this, like respect, by deeds not just by words. Thus action, not merely creeds, is required before democratic society is willing to bestow the distinction of professional character upon any activity. In that endeavor, the progressive philosophy of the Industrial Engineer is the key ingredient for ultimate and lasting success.

The Development of Industrial Engineers

There was general agreement that the responsibility of education is to provide a sound basic engineering course. It should be of comparable academic rigour to other engineering courses, and should prepare the student to be no less flexible before a variety of engineering problems than graduates of other engineering courses.

It was considered desirable to have the student taught in an atmosphere contemplated to prepare him to be effective as an Industrial Engineer in industrial situations. The disciplines included in the curriculum could be those peculiar to Industrial Engineering, but would have to be organized to satisfy the conditions stated in the paragraph above. Selection of desirable disciplines was recognized as an area of many problems, and one requiring considerable attention.

It was fully agreed that recognition in the curriculum should be given to human behaviour as a component of the Industrial Engineering design area. The Industrial Engineer faces human problems in both the design and installation phases of a project.

It was recognized that a wide range of abilities are desirable in the graduate engineer, but that a college course could not instill them all. There was feeling the quality of the graduate might be improved by seeking a better quality student to take the Industrial Engineering course. Factors discussed which might accomplish this include improved vocational guidance, better understanding of the Industrial Engineering field, and as suggested earlier, the offering of a superior engineering course.

There was agreement that industry could help education by fostering better understanding of the field, and by offering counsel to the colleges on the makeup of their programs. There appeared to be agreement that it was industry's responsibility to guide the graduate through the period of transition from the academic to the industrial environment. It was considered industry's further responsibility to further develop the graduate to take his place as a contributing responsible member of the industrial organization.

Industrial Engineering Publicity

The group agreed that publicity is the dominant factor in putting Industrial Engineering before the public and that considerably more favorable publicity is needed. The group discussed at length three important areas that should be reached by Industrial Engineering publicity: management, the government, and high school students.

A. *Management*

Management should be told what Industrial Engineering can do as well as what Industrial Engineering is and what it is not. It is often desirable to tell management what other companies are doing with their Industrial Engineering staffs. Management should be told these things both to allow them to properly use their Industrial Engineering manpower to produce better results and to insure that Industrial Engineering can gain its proper recognition in the eyes of management. In general, the best ways to inform this group are through the "JOURNAL OF INDUSTRIAL ENGINEERING", trade magazines, professional papers and encouragement of attendance at lectures and conferences. Several other specific means of getting this information across to management were suggested:

(1) American Institute of Industrial Engineers' surveys to find out what other companies are doing in the Industrial Engineering field, to assemble, analyze, publish and distribute this information. Reference was made here to the excellent job that the American Management Association does in publishing its reports and surveys.

(2) The publication of case histories illustrating in-

stances where Industrial Engineering has performed a unique or extremely effective service.

(3) Public service projects such as now carried on by several American Institute of Industrial Engineers' chapters. For example, work with hospitals and other institutions in the application of Industrial Engineering techniques.

B. *Government*

Government should be told what Industrial Engineering can do. There seemed to be a feeling in the group that the higher levels of government are not familiar enough with Industrial Engineering. One suggestion for action in this area was to let government people come and see Industrial Engineering programs in industry.

C. *High School Students*

The well-known problem of encouraging high school students to major in the sciences or engineering in college was brought up. There was a feeling in the group that Industrial Engineering should do much more to encourage high school students to take up this career. Plant visits for high school groups to see how Industrial Engineers work were suggested. Career counseling of high school students who are interested in this field by people who are active in it was suggested. The group noted that other branches of engineering have a considerable amount of published material for high school teachers and counselers to use while Industrial Engineering lacks in this area.

In searching for one means that could be used to fill many of the needs that were outlined in this area of publicity the group leaned towards a short motion picture film or sound-slide film which describes what Industrial Engineering is, what it does, and illustrates career opportunities. It was thought that something like this could be used to solve a number of the problems that were brought up during the earlier discussion. There was agreement that the American Institute of Industrial Engineers should appoint a committee of several people from industry to secure the necessary money to produce the film, to prepare a suitable script, to handle the production of the film, and to arrange wide distribution.

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The Industrial Engineer Uses Operations Research*

By James W. Thompson, P.E.

Chief Industrial Engineer, Argus Cameras, Incorporated

I am an industrial engineer.

My degree is in industrial engineering. My job title is Industrial Engineer. My mode of work, my way of thinking through a problem, is as an Industrial Engineer. In spite of other assignments, such as operating a tool room or a maintenance department, I continue to act like an Industrial Engineer. I take pride in my conduct as a Professional Engineer practicing Industrial Engineering.

I mention these things only because I wish to establish the point of view that I hope to maintain in my discussion. When Mr. Eskew offered me the honor of participating in today's program, I refused to talk about an Operations Research project. I'm not at all certain as to whether I've ever been involved in a pure Operations Research project. I have, however, gained quite a bit from Operations Research applied to Industrial Engineering problems. This experience is my only claim for a place on this program.

With your patience, then, I would like to discuss:

1. The sometimes parallel and sometimes diverging aspects of Industrial Engineering and Operations Research approaches to a problem.

2. Operations Research as a natural addition to the Industrial Engineering group.

3. The value of Operations Research to the Industrial Engineering group at Argus Cameras.

I. Is It Operations Research or Industrial Engineering?

Two years ago, this was a confounding question to me.

Not only was it a question to Industrial Engineering but other groups as well. Our Quality Control people looked at some examples and snorted "That's just statistical analysis, the same sort of thing we do every day." Our Production Control Manager visited a plant where Operations Research had been used in inventory control. His report was to the effect that they had schedule boards, forecasts, and the same tools that we were using. I attended a lecture by a recognized authority in Operations Research. At the completion of the lecture, a Professor in Industrial Engineering severely rebuked the speaker for calling an ordinary Industrial Engineering problem an example of Operations Research.

Some of our corporation officers were certain that these things were not the same. After all, some of our officers even read the book. I was chastised for not doing what the book said should be done. I suspect many of you here got into Operations Research just as I did—in self defense.

At one of my first Operations Research training courses I got my answer. One of the instructors was discussing the Operations Research approach to setting up an industrial production research program. I nearly fell off my chair. It was almost identical to an approach our Industrial Engineers had used in setting up our own optical processing research program.

It appeared that there is no difference between the methods of solving *some* problems by Industrial Engineering techniques and the approach of Operations Research. In support of that statement, you can read Operations Research reports on projects completed by people who knew nothing of Operations Research.

Similarly there are many Operations Research examples published that no more embrace the fundamental concepts of Operations Research than does a stopwatch exemplify an Industrial Engineer. I refer now to the tendency to standardize "cook book recipes" for the Operations Research solution of industrial problems.

Back now to my point of view. As a Chief Industrial Engineer of a plant, it doesn't matter whether Operations Research is Industrial Engineering or vice versa. My group has more problems to solve than time or money will ever permit us to solve. My emphasis is on the solution of the problem, by the best practical means available. The concepts of Operations Research, its techniques, and the findings of other Operations Research projects have helped us in the solution of problems. I welcome Operations Research for the tremendous contribution it is making to my profession.

The question of definition may be important to the research physicist working on Operations Research. It may be important to the President of a company who wondered if he has been taken by a fancy name. The only question that is important to this Industrial Engineer, however, is "Am I getting all the help I can from the Operations Research movement—or any other movement?"

Still from my point of view, laboring on the significance of the label is like trying to decide the difference between

* Based on a presentation to the Southeast Regional Conference, AIIE, Atlanta, Georgia, February 24, 1956.

a Time Study Man, a Manufacturing Engineer, an Industrial Engineer, and a Systems Analyst. Time, place, problem, and personal characteristics make the difference, not the title. The fact that an engine lathe is suddenly called an instrument of production, doesn't change the nature of the problem study.

We can draw a parallel between Operations Research and Automation. There is little in the pieces of either title that cannot be found under another title. Operations Research and Automation are more symbolic than titles. They are symbolic of a tremendous growth in the field of management. The cycle of development is an expansion of previous cycles that may have been under different headings. Let us just be professionally grateful for the cycle.

II. Operations Research is a Natural Addition to the Industrial Engineering Group

My limited experience with Operations Research has shown that it can contribute to the skills and value of an Industrial Engineering Department. I sincerely believe that it can and will be embraced by progressive Industrial Engineering groups. My assumption is that this is a natural assimilation, not forced by decree or directive. If so, then Operations Research will enter the Industrial Engineering field regardless of the show of hands taken at this conference; regardless of the findings of a national research committee.

A. *New Techniques and Concepts Are Normally Brought into Management through the Industrial Engineering Group*

It is the duty of Industrial Engineers in companies the world over to find needs, investigate new techniques, and consider applications. It is natural, then, to find management groups turning to Chief Industrial Engineers for opinions on Operations Research.

In my remarks I am not choosing sides on the issue as to whether an Operations Research group is part of the Industrial Engineering Department or completely separate. At Argus we have done both and used varying combinations. It is the nature of the problem and the skills available that decide the organizational status.

This has its parallel in this assembly's experience. All Industrial Engineering is not practiced in the Industrial Engineering Department. Heaven forbid! We spend a lot of time teaching foremen to use Industrial Engineering techniques. Our organizations are full of examples of Procedure Analysis and similar special groups set up outside of the Industrial Engineering Department.

The history of Industrial Engineering is full of examples of first investigating and using tools such as production control and statistical quality control, then later transferring them to an independent group.

B. *The Industrial Engineering Group Already Has the Problems that Operations Research Assists in Solving*

Making decisions by the "seat of the pants" technique is not necessarily wrong. There are many decisions that are worth no more than that amount of effort. As the value of the right decision increases, the amount of justifiable analysis increases.

The Industrial Engineering department faces a wide range of decision analysis work. Economic administration of a department dictates that we devote time and effort in accordance with what the solution is worth. We need a wide range of decision tools.

The Operations Research literature is full of information on the choice of a suitable problem. The Operations Research team is continually facing tests of feasibility of its solutions. When Operations Research is used in an Industrial Engineering Department, many of these difficulties disappear. Problems we have. We are in the best position to decide the "degree" of analysis justified. We can best determine the proper problem that will add to the success list of the concept of Operations Research.

C. *Operations Research Techniques Can Be Added To, and Complement, the Industrial Engineering Techniques*

I was once concerned because I feared Operations Research would be totally new and completely different. There is much about it that is new and different to some of us. In general, however, Operations Research methods are a natural development from the basic roots established in research, engineering, controllership, quality control and general industrial management. The Operations Research problem area is that traditionally assigned to the Industrial Engineer. The concepts are not foreign to them. Operations Research concepts, its problem area, and its methods can be added to the basics we have in Industrial Engineering.

For instance: Industrial Engineers have long been using 3D models for plant layout. As such, they have been static things, a presentation means, or a focal point for discussions. A model in the Operations Research senses is a dynamic thing; a small representation that can be manipulated.

We added the concept of manipulation to the customary plant layout techniques. In other words, we ran production through the 3D layout. We scheduled, manned, moved material, and stored our parts. As a result, we went through a complete changeover in one of our processing methods with full confidence in the outcome. In the words of the foreman, "If I had it to do over again, I wouldn't change a thing."

The pace of addition can be varied to suit the Industrial Engineering group. By adding a little or a lot, you can gain in proportion. You can continue to perform your regular functions. A separate group facing accomplish-

ment deadlines doesn't have this variable rate of absorption when it adopts Operations Research.

D. *The Use of Operations Research Is a Natural Step for the Industrial Engineer to Improve His Analytical Ability*

I remember that my Latin teacher stressed the value of Latin to improve my knowledge of the English language. Similarly, I find that Operations Research improves my analytical ability. It has forced me to deviate from cook book techniques.

Take for example what we commonly refer to as the scientific approach. When you use the term in relation to Industrial Engineering, I have a fair concept of what you mean. I have always felt wholly inadequate when I tried to explain it to others. Reading in the general literature has never seemed to quite give me the expression I sought. Operations Research people have done an excellent job at this.

Imagine what a logician, a philosopher, or a research physicist must have faced when he tried to approach his first industrial problem. The environment was strange, the people had strange ideas, and facts were apt to be unreliable. After a couple of near misses, these people proceeded to spell out, for one another, how to approach a problem. The talents of the scientist and the philosopher have done an excellent job of explaining what we so loosely called the scientific approach.

I have been happy to find that others are in agreement with some of the things I am advocating today. Mr. D. F. Howe, Manager of Management Methods Research, The Proctor and Gamble Company, placed their first Operations Research project in the Industrial Engineering Department. He gave these reasons; explaining that they seemed right in their organization, but would not necessarily apply equally to other companies. These are not quotations, but my interpretation of what he said at a recent conference.

1. The Industrial Engineers had proven that the Operations Research type of approach has value beyond doubt.
2. The Industrial Engineers had already begun to explore Operations Research for help in their problems.
3. Operations Research could fit into the plans for future growth of the Industrial Engineering function.
4. A research group existed in Industrial Engineering.
5. Industrial Engineering personnel included people with the background and inclination for this type of work.
6. Industrial Engineers had the great deal of company information required by the Operations Research project.

III. Operations Research Has Been of Value to the Industrial Engineering Group at Argus Cameras, Incorporated in Several Ways

A. *The Decision Costing Concept Has Been Made Stronger by the Added Techniques from Operations Research*

Industrial Engineers have been closely associated with standard cost systems that have grown up in industry. Indeed, it was the Industrial Engineer that developed the measurement and control devices that enabled standard cost systems to achieve their present stature. That experience has many times served to limit the breadth of our quantitative measures.

In our plant, and in many others I have seen, the Industrial Engineering group is used to "cost" proposals; whether they be purchases of equipment, choices of material, or analyses of various process methods. The common approach is to make the "cost" figure fit whatever inventory evaluation system exists in the company. We get into long, laborious—and useless—discussions of burden allocation in trying to parallel the cost system.

The criterion of our ability to guide decisions has been the extent of our agreement with the cost system. It used to be a practice in our company—and still is in many of our neighbors—of having a later cost report issued to compare with the original proposal analysis. If the figures agree, the Industrial Engineering department is pretty good even if conditions are completely different than those predicted. If the figures don't agree, then the Industrial Engineering department is still pretty good because they can show that supervision slipped, the operator was lazy, or that the tool designer was bullheaded. I have found that the alibi analysis usually takes more time than did the original "costing."

In my early studies of Operations Research, I was fascinated by the quantitative aspects, probably because it was a break with tradition. At first, my studies on the subjects of value systems, intuitive analysis, approximate measures, imputed values, and inferred values were largely the result of aroused curiosity. Out of it has come, however, a new concept of the role of the Industrial Engineer in costing.

At Argus, we call this Decision Costing. It is usually expressed in dollars, a measuring unit very familiar to those making decisions. We frankly advise, however, that the values may never agree with our cost system reports.

Our philosophy is simply this. A decision involves alternates—purchase or make, to buy a machine or not, paint or chemical finish, 11ST Aluminum or 17ST Aluminum. We will examine all factors that affect the decision and use only those factors that affect the decision. If the amount of supervision is the same, we will ignore cost of supervision—instead of adding a percentage. If the lighting remains the same—we won't allocate the light bill. Sometimes only the difference is measured, a real time saver. The factors that are different are costed, but our costing means are not traditional. The only accuracy restriction we put on our costs is that they do discriminate; that is, they do relatively point up the difference. Our final answer indicates the best course of action to be taken but never makes claim for accounting profits.

Our further thinking, after checking, is something like this. If one course of action is better than another, we should take it, whether the savings be $100, $1,000, or $10,000. What matter then if we predict $1,100 and it

later proves to be only $900. If, later, unforeseen factors develop that make the whole venture a loss, that is simply regrettable. If we had it to do over again, we would make our choice only on what we know.

We had to defend this philosophy at first. By this time, however, even the accountants show savings in the cost centers where decision costing was applied.

What does this have to do with Operations Research? This is just a little gimmick that has permitted us to adopt a host of Operations Research techniques without dropping our traditional role. We can now put quantitative values on factors that we listed formerly as intangibles. We use imputed values and approximate measures and no apologies necessary. We deal with probabilities, and inference. We have found that we can quantitatively guide more decisions than we could without these techniques. For instance:

1. *Training curves to analyze costs of schedule changes.* We felt, intuitively if you please, that there must be costs involved in changing production schedules. These costs don't appear in standard labor rates and heavy burden rates. The cue to this measurement came from some Operations Research literature on a use of the so-called training curve. We found that our experience on changing schedules, and the resulting output, had a remarkable fit to training curves. As a result, we can now plug in certain information about a change in schedule and reasonably predict its effect on assembly output. This prediction is used in a whole series of decisions—the production schedules in feeder departments, training loads, shipping schedules.

2. *Statistics, inventory mathematics, and Monte Carlo methods to analyze a central packing proposal.* We could see some material handling advantages in changing our methods of packing finished cameras. The decision faced was, pack at the end of each assembly line or establish a central packing department.

We had severe space limitations that all but stopped us. We just couldn't bring all loads of shipping material into the central pack area—there wasn't room for the ebb and flow. We had, in our analysis, several direct savings in our proposal. There were likewise some direct costs. We know the cost of double handling but not how often.

Operations Research training had taught me that Monte Carlo methods were accepted practice. We tried out the whole range of possible changes on paper—changes in vendor shipping schedules for example.

We used rather elementary statistics to explore our chances of running out of material, of getting too much to store, of overloading the elevator capacity.

In combination with our inventory mathematics study, we introduced approximate costs—costs of deviating from economic lot sizes, costs of carrying inventory.

At no time did we finally arrive at a fixed predicted savings. We merely established that this was the proper decision, and that it was worthwhile. We had confidence in our solution—and really needed it in the hectic days of the conversion. The results, reported by the accountants on the comparative Profit and Loss statement, indicate that this is a wholly satisfactory way to approach a problem.

3. *Previous problem answers applied to the decision for individual or group assembly stations.* Each little bit of information gained in a decision problem helps to make the next decision. The above value methods, together, will help answer another question. Which is better for us, group assembly or individual assembly stations? People who have gone to individual assembly, point to savings in losses from unbalanced lines. People who have gone to groups, point to savings in inventory. We will want to cost it out.

Our new found concept of learning rates will help us measure the savings due to the schedule flexibility of the individual station, the costs of frequent change of operations. The approximate costs of carrying inventory are known from another study. A little of old man probability and a dash of Monte Carlo will give us our answer on this.

We could find out that we were right all along. Then I suppose I could say we didn't need Operations Research, but I won't.

4. *The use of decision rules.* The urge to simplify decisions comes to the front as soon as you shed the exact accounting strait jacket. Whenever a pattern of similar decisions starts to occur, we find ourselves developing what Operations Research calls decision rules.

Again, you have decision rules without Operations Research. A formula for economic lot sizes is considered to be a decision rule. There are some beauties available. Ours is a simple thing, hardly what you would expect from an Operations Research study.

There is a difference between a decision rule developed through Operations Research and one that may be written as an executive policy. Our economic lot size formula is simple because we first determined the results of considering each item customarily included in a formula. We simplified when we knew the minor error introduced.

B. *The Logic and Orderly Analysis of Operations Research Have Been Excellent Selling Tools*

One of the eternal problems of an industrial engineer is that of selling his solutions. You and I are constantly searching for fresh approaches to this problem. I offer that the logic, the orderly analysis, and the theory behind many Operations Research techniques are excellent selling tools. For instance:

1. *The logic of the waiting line theory.* The logic of the waiting line helped us to sell the results of a year's industrial engineering effort. We had been involved in a thorough analysis of our shipping activity. We had revamped our warehousing, rearranged our feeder lines, installed better material handling, and installed cost control devices. The results, however, were not nearly as good as our measured potential.

Without going into detail, let me say that this was

largely the result of operating to a restrictive sales service policy, rather than to optimum economy procedures. We had to sell the sales department, who are extremely critical where customer relations are involved.

We had all of the ingredients of a waiting line problem, randomly varying input and fixed output level. The logic of the phenomena was all we needed however. This was my approach. a. I used a very simple example from one of Symons papers to explain what happened in a waiting line situation. b. I then displayed the data we had gathered to indicate that we had a waiting line problem.

With understanding, our sales group dropped their dogmatic attitude. We were able to work out a system that gave them the service standard they desired without seriously affecting our cost reduction effort.

Incidentally, the cost department advises that we are saving about $7,000 a month in that activity.

C. *The Study of Background Mathematics and Statistics Has Assisted in Problem Solutions*

Once we got started on this Operations Research merry-go-round, we got help in a variety of problem areas. We found that a little help rubbed off with each paper read, each conference attended, each problem approach.

I note that Mr. Howe of Proctor and Gamble relates a similar experience. "In 1953 . . . our Industrial Engineering people had begun to get a better feel of what Operations Research was . . . we had begun to make more and more use of mathematics . . . which was giving our cost control studies quite a lift." For instance:

1. *Multiple correlation by intuitive reasoning.* We were searching for a budgetary cost control device in one of our service areas. As was to be expected, operating costs had little to do with production. We thought we knew the factors that should influence costs and had our recent cost records for a performance history. In our desire to be scientific we set it up as a multiple correlation problem.

I see that some of you have been through this before and already know that it didn't correlate. What should have been and what was are often two different things.

About that time I read the Evans and Hoffenberg paper in the interindustry study. The authors devote about six pages in defense of a method of intuitive reasoning on a problem of this nature. It was less work than multiple correlation and gave a workable answer.

2. *Randomly occurring operations.* One of our standards men was having quite a time with a multiple spindle standard. A portion of the operator's work was involved in things that happen now but don't happen then. In a cursory standards fashion he had averaged them in.

The problem of course, was simply this. When the randomly occurring items didn't happen, the operator waited for the process cycle. When they did happen, the process cycle was lengthened and production was permanently lost. This looked so much like a waiting line problem, that I dug out the papers on the New York Port Authority traffic studies.

The solution to the problem was more simple than queueing theory. Based on past records, the standards man estimated the average and 3 sigma limits of the probability of occurrence of each of the 15 odd independent variables. Using standard "area under the normal curve" tables he arrived at the probable average extension of this process cycle.

It worked.

3. *Interference studies.* We struggled with probability theory on multiple machine assignment. A little research informed us that Dr. Dale Jones of Georgia Tech had spent a few years on the subject. In four days time he saved us, easily, a year's work.

4. *Matrices.* I could go on for several examples of the use we have found in matrix presentations. Even if you never take the next analytical step, linear programming, a few of the short cut techniques are helpful.

Part of my responsibility is the forward planning of the manufacturing facilities. My group is continually forecasting building and space requirements and their relationship, one to another. We are continually interpreting sales trends and new product forecasts in terms of space. To keep this on a routine basis, we have developed a method of feeding information into a matrix presentation of our two years hence requirements. Someday our production people will be able to present and trust this information after linear programming manipulation. In the meantime we use its analytical principles.

Floor space variables are arrayed against relationship factors, usually material flow and contacts. In order of importance, we explore possible arrangements. Templates are arranged on an overlay of present and possible facilities. We wind up with a best and alternate solution to be used for forward planning. We don't get too excited over differences in opinion. After all, we have two years in which to settle them.

The results of these studies are continually used for financial planning.

D. *Operations Research Has Opened the Door to Work in New Problem Areas*

Industrial Engineers are convinced that they can improve anything under the sun—aren't we? If they would only let us try it! In our experience at Argus, we have found that people receive an Operations Research project with interest, even though they may have resisted an Industrial Engineering project.

For some time I had been making a bid for work in production planning and inventory control. I was convinced that the introduction of such things as economic lot sizes and Gantt charts would revolutionize the department. I am glad now that I was never accepted.

This was not a problem to be solved by cookbook techniques under any title. It was finally necessary to arouse dissatisfaction with the state of affairs throughout the organization. This was accomplished by riding the Opera-

tions Research interest with a training program on Operations Research analysis tools.

Early in my interest in Operations Research, I discovered that the Planning Manager likewise had an interest—even though in an opposite direction. We dared each other into attending the Case Conference on Inventory. We visited two plants where some work had been done. Later, when my boss was criticizing me for not getting an Operations Research project started, I goaded my friend into a trial in his area.

We hired a consulting firm for this project. Their first step was to survey our problems and present an approach for our approval. Essentially their assignment then was to help us to help ourselves. These steps were taken to accomplish their assignment.

1. Training of our people.
2. Organization of problem teams.
3. Guidance of teams in the major problem areas.

Training subjects were in inventory mathematics, linear programming, and other analytical techniques that could be applied to the problem area. Training was across organizational lines. The programs were fitted to the people attending. The top executive group met at a series of luncheons for a briefing on the language-appreciation, it was called. The lesser executives met in evening programs. The working level met in concentrated sessions away from the plant.

Teams were formed for many problems, large and small. For example, an industrial engineer and a planner tackled the problem of programming barrel finishing operations.

The guided projects were three in number.

1. *The Purchase versus Make study* was an analytical analysis of the decisions and costs in this problem area.

The camera business is seasonable, yet Argus maintains a stable employment level. One of the factors contributing to stability of employment is our use of the Purchase-Make option. We maintain limited manufacturing capacity, farming out operations at peak sales periods, recalling them at lower periods. The objective of Purchase-Make decisions are to maximize profits under the conditions I have described. We do this through a comparison of costs of both options, thus arriving at a profit advantage for one option over the other. Maximum profit is realized by simply scheduling parts to our facilities in order of profit advantage.

2. *Inventory Management.* A practical application of the theory of inventory mathematics. It was a study to determine the most profitable manufacturing program in our fabricating departments.

One of the best known results was the partitioning of inventory, a very workable manner of exercising control of inventory in accordance with its value. We now have better control of our inventory and a reduced overall value at a greatly reduced cost of control.

3. *Scheduling and loading.* Briefly, this study dealt with the determination of correct starting dates and the costs of deviating from these dates.

The Factory Manager, the Planning Manager and I met jointly to determine the feasibility of the consultants' proposal. Once the project was initiated, the Planning Manager exercised full executive supervision over all phases.

IV. Conclusion

A. *Summary*

I don't consider what I have said here to be an example of an Industrial Engineering Department that has been changed to an Operations Research Department. What may be here is an example of an Industrial Engineering group that has taken only a few faltering steps toward the use of Operations Research. Certainly our plans are for far more than we have accomplished. It may be only an example of what your next step will be. If so, I have served my purpose.

B. *Speaking to Both Groups Present, the Industrial Engineer and the Operations Research Specialist*

To the industrial engineer, I would like to say that there is nothing to fear in the Operations Research movement. You don't have to suddenly be a Ph.D. to hold your job. On the other hand, you needn't look at Operations Research as a new field, a great big monster that must be mastered before you can use it. Each little bit you master will immediately help you. The more you know of it, the more your present effectiveness will be increased.

To the Operations Research professional, please be patient with us Industrial Engineers. Offer us a little step at a time, and more important, a step oriented to our needs. Don't frighten us by showing us first a mathematical expression—one that took probably three months to develop. We want to join you, but sometimes have trouble with your language.

TEACHING POSITION AVAILABLE

Young Person with B.S. or higher degree in I.E. or I.E. option and with two to four years industrial experience desired for position as Assistant or Associate Professor in strong long-established Industrial Engineering Department in large Mid-Southwest College. Work will be about equally divided between teaching industrial engineering courses and operations research. To be eligible, person must be articulate and able to develop research projects with industry. Work toward M.S. and Ph.D. can be pursued in residence. Opportunity for consulting work. Computer is available. Salary equal or better than industry scale.

Write: **Journal of Industrial Engineering**
Dept. G, A. French Building
225 North Avenue, N.W.
Atlanta 10, Georgia

The Industrial Engineer and Social Progress*

By Walker L. Cisler

President, The Detroit Edison Company

Less than 50 years ago (in 1911), a meeting not unlike this one was held on another campus—at Dartmouth. The Tuck School Conference on Scientific Management brought together nearly 300 engineers and industrial representatives. Such names as Taylor, Barth, Gantt, Emerson, Cooke, and the Gilbreths appeared on that program. History has confirmed the significance of that meeting and has recorded the names of many of those present among the great industrial engineers of our times. One who was there, Lillian Gilbreth, in the years between has earned the love and respect of all of us for her great service to the progress of management. For her "fundamental contributions to the general body of management thinking" she was this year awarded the Gold Medal of the International Committee of Scientific Management, the highest honor we can pay to one of our profession.

That historic meeting at Dartmouth gave needed impetus to the extension of engineering principles to the field of management. Out of those discussions came ideas and principles and a spirit of enthusiasm which helped lift production, employment and the standard of living in the United States to the highest levels in the history of mankind. In a period of less than 50 years, hours of work have been reduced more than one-third while real earnings in terms of purchasing power have more than doubled. Machine power has to a large extent replaced manpower as our source of energy, but the numbers of gainfully employed have steadily grown, with an ever increasing proportion of our population being able to build up adequate retirement income through industrial retirement plans, social security, and personal savings.

The new industrial revolution which is already under way will be characterized by the development of atomic power and many other applications of nuclear energy to the advancement of living standards. It will see the rapid development and application of electronics to the simplifying and speeding up of thousands of industrial processes, further relieving human effort from routine and time consuming tasks, making more time available for the creative work and planning that only man's mind can do. Digital and analog computers will hasten the solution of complex problems and assist with the clerical and accounting procedures necessary for the conduct of business. Such concepts as automation and operations research which are scheduled for discussion in your meetings will become commonplace.

These and other engineering developments and new industrial methods will open great new opportunities for increasing production and further raising the standard of living, not only for ourselves but for all the peoples of the world. With these new opportunities comes a greatly increased responsibility on the part of management of industry, of unions and of our government to work together to utilize these powerful new forces and techniques in a way which will truly contribute to best interests of the greatest number of people. Progress occurs only as an experience shared by many. This is true not just in a local sense as it applies to the employes in our companies and our industries, but it is also true in a national and international sense. In the United States, where all have shared the benefits of technological progress, we have reached the highest standard of living in the world. Our willingness to share our gains, both financial and technical, with the countries of Europe since the war is evidence of our awareness of the need to extend the experience of progress to others if we would preserve our own gains.

I am confident that all of us here today are aware of the importance of the human factor in technological progress. Yet, in our pursuit of efficient methods and lowered costs it is easy to lose sight of the fact that motivation of individuals is one of the essential components of high productivity. When new methods are installed without full concern for those affected we fail to realize the full potential for progress and may build resistance which postpones the gains of improved technology.

The pioneers of scientific management at the 1911 conference at Dartmouth were not unaware of this truth, although some of their contemporaries did overlook it in the years that followed.

I would like to recall for you the insights our early industrial engineering pioneers had for the human element in technological change. Frederick W. Taylor, whose life and work are well-known to you, first became concerned with management methods as a gang boss in a steel plant at the age of 24. Knowing that production was far below what could reasonably be expected he did what he

* Based on a presentation to the Cornell University Industrial Engineering Seminars, June 15, 1954.

could to force his men to put in a fair day's work. He finally succeeded, but the experience was so distasteful to him that he became concerned with the human relations problems which brought about such conflicts. His subsequent studies of work standards opened the way to an entirely new concept of industrial management based on cooperation rather than conflict. He became concerned with not only the output of the worker, but also with the effects of the facilities and conditions provided by management for his work. The worker was not asked to work harder, but simply to use the better methods and tools provided. As a result, production increased, wages were raised, and the benefits of a more scientific approach to management problems established in his company. The record shows that Taylor never again had any serious conflicts with the workers in any plant which he served as engineer or executive.

Later, when he had more fully developed his principles and philosophy and when his concept of scientific management had become widely recognized, he was called to testify before a special committee of the House of Representatives. This was in 1910 before that historic conference at Dartmouth. It was during these hearings that Taylor developed the idea that true scientific management required a mental revolution on the part of both management and workers. He said they must accept the philosophy that the interests of both management, labor and society in the long run call for ever greater output of want-satisfying commodities. Output requires expenditure of human and material energies; therefore both workers and management should join in the search for discovery of laws of least waste.

Taylor recognized that the emphasis on techniques and processes alone would not serve the objectives of good management. In his words, "The mechanism of management must not be mistaken for its essence or underlying philosophy. Precisely the same mechanisms will in one case produce disastrous results and in another the most beneficial. The same mechanism which will provide the finest results when made to serve the underlying principles of scientific management will lead to failure and disaster if accompanied by the wrong spirit in those who are using it."

One of the important principles of management laid down by Frederick Taylor was that of the continuous, intimate, friendly cooperation between management and the men. Himself an expert in scientific procedures, he recognized the importance of teamwork and the active participation of the worker in developing new methods.

The Gilbreths' first concern was for people rather than technology. They saw improved methods as a way to reduce human effort while at the same time increasing the end product. The equal concern for men and methods is amusingly illustrated in that now well-known and touching account of their lives, "Cheaper by the Dozen". In their drives with the children packed in the Pierce Arrow, father would point out the fine points of engineering and architecture in the bridge under construction while mother would quietly call attention to the workers who were building the bridge. First concern for the well-being of people everywhere has characterized the outstanding career of Lillian Gilbreth.

During the years since that first Industrial Engineering Conference at Dartmouth we have seen the growth of an industrial system which not only raised the peacetime living standards far beyond the fondest dreams of the industrial engineering pioneers, but also provided the guns and ships and planes that kept us and our allies free through two world wars. With the threat of further aggression still hanging over the free countries of the world, we have developed an economy which can supply the costly and intricate weapons of war and at the same time raise our standards of living, make work easier, and provide additional security and benefits for the American worker.

Recognition of the productive capacity of the United States has led many of our European allies to send so-called "Productivity Teams" to this country since the end of the second world war. Composed of engineers, industrial leaders, union representatives, government officials and church dignitaries, their purpose has been to learn the reasons for the high productive capacity of American industry so they can bring the same benefits to their own countries. They have studied our organizations and talked with our employees and managers. They have watched our production processes and examined our business methods, comparing them with their own. They have brought with them a critical, objective, sometimes sceptical point of view. They have seen us and our institutions as only an outsider can see us. My own Company has been host to many such teams from England, France, Norway, The Netherlands, Germany, Austria, Japan, Italy, Greece, Korea and other free countries. I'm sure many of you have also talked with these visitors, shown them your plants and discussed your plans and problems with them.

I have been deeply impressed in talking with our friends from overseas at the frequency with which they refer to the human factors in our industrial enterprise. They see behind our efficient methods and high production, the spirit of cooperation and teamwork which characterizes American industry.

I would like to quote for you from a talk by Maurice Bonzel, President of Trefileries Bohm Company, of France, because I believe it illustrates so well the considerations which I would impress on you today. As Group Leader of one of the French Productivity Teams, Monsieur Bonzel addressed a National Trade Association on his return to France concerning his team's impressions of the United States.

In answering the question "What have you seen there that is interesting?" he had this to say, ". . . . We have seen an immense population, in which good spirits predominate, express by its work and its way of life, its individual faith in human possibilities, both at the level of the individual and of the nation. . . .

"This importance given to the individual, to the personality of each, we noticed everywhere in the U.S.A. at all times, together with a high sense of individual responsibility; you find no abstract anonymity in the United States, you find men who live, think and act with a strong sense for the concrete things. . . .

"From the first we were struck by the two following facts:

1. There is no essential difference between American wire drawing techniques and ours.

2. Manufacturing costs are of the same order of magnitude in both countries, although frequently a little more advantageous for the United States plants in spite of the fact that wages are considerably higher in the United States. . . .

"By and large, technical processes are identical, we were able to verify this fact; it did not come to us as a surprise, however, for we knew that as soon as a technical improvement is discovered, its use is immediately disseminated all over the country, and it soon becomes known in all the countries of the world where constructors try to sell their machines and their processes. . . .

"Because of the rapidity of the visits and of unusual (for us) proportions of the plants we were going through, it took us quite a while to understand how, with a similar number of workers, their production was three or four times as high as ours. . . .

"Now, can we use the same methods and pay our workers much higher wages, similar to those which workers earn in the United States for work that is often easier than here? . . .

"To word the question like this—limiting it to the purely technical aspects of the problem, is in my opinion a grave error. The high American productivity is not only the result of technical progress, it is the ultimate outgrowth of philosophy accepted and applied by a whole nation at all levels of production, distribution and consumption. . . .

"Whatever the type of production, it always employs less men than in France. In terms of man-hours, it takes the United States four times less man-hours to manufacture an automobile, three-and-a-half times less to make a pair of shoes, five times less a shirt or a suit, ten times less a pair of socks, six times less a refrigerator or a washing machine. . . .

"The same is true in agriculture, where eight million American workers feed a population of 160 million inhabitants, while in France an almost equal number of workers, i.e., seven million, are needed for a population of 42 million. . . .

"Although farmers, who know how to make themselves heard in Washington, make highly substantial profits, food does not take up more than 30 per cent of the average family budget in the United States as against 75 per cent in France."

Maurice Bonzel concluded his remarks by saying, "It is indispensable that the increase in productivity which is the only rational and durable solution for an improvement of the living standard and social peace, should be sought on a broader plane by all men of good will in all walks of life."

I have quoted at some length from Monsieur Bonzel's talk because I believe he has described, perhaps even more vividly than we ourselves can do, some essential values and characteristics of our present-day American economy.

What the pioneers of industrial engineering learned through personal experience, and our friends from overseas have observed in watching us at work, is being substantiated in the growing body of research findings in the field of human relations. Oddly enough, it has only been since the war that we have turned our advanced methods of research and scientific investigation to the study of the human relationships in our companies.

Here again the predominant spirit of cooperation and mutual assistance has played an important role. Much of the human relations research work which has been going forward has brought industry and the campus together in a kind of research partnership. The social scientists have found the plant and office a practical laboratory for their studies of the human factors affecting production and employe satisfaction, and management has applied some of their findings to the solution of day-to-day problems.

In my own and other companies participating in human relations research projects with groups like the New York State School of Industrial and Labor Relations at Cornell and the Institute for Social Research at the University of Michigan, new and convincing evidence of the importance of concern for the individual is beginning to emerge. Management leadership has been identified in these studies as a major contributing factor to high morale—high productivity work groups. Effective industrial leadership is characterized by an active concern for the welfare of every member of the work team and for his individual growth and development. It recognizes the need of each employe and supervisor to have a sense of personal worth in his work and to participate actively in setting goals and objectives, and in having his ideas on policies and methods given sincere consideration. Such leadership follows the principle enunciated by Taylor nearly 50 years ago—the continuous, intimate, friendly cooperation between the management and the men. We have a great deal yet to learn about how teamwork and cooperation can best be developed in large organizations but there can be little doubt that these factors are the keystone to continued increases in productivity and greater social progress.

It is, therefore, extremely important as we put to work our rapidly growing technological know-how in developing increased efficiency of operation that we are mindful of the human factor in productivity. We have it within our power to raise the standards of living, of health, security and leisure to levels never before thought to be possible, both for ourselves, and by our example and help, for all peoples of the world who believe in and will practice the ways of freedom.

Productivity—A Report on the Israel Institute of Productivity

By Alan J. Levy

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Since the end of the Second World War there has been in European and Asian countries both a recognition of the need to increase their Societies' productivity, and a deliberate attempt by governments on these continents to push production and productivity ideas. Productivity centres are the usual institutional technique used to accomplish these ends; this article describes the Israel Institute of Productivity as an example of this new Institution.

Most productivity centres were started with governmental funds originally under the impetus of the Marshall Plan and other American aid programs. Each country has used various criteria and techniques for establishing the managing board. In Israel the Productivity Institute is a semi-government organization composed of the representatives of the three main economic groups in the country—the government, industry and labor.[1]

A productivity centre's main objective is raising productivity and thus production; note the difference in definition between these words. Production is total output irrespective of the way output was achieved. It can be increased in two ways: by increasing production facilities—larger capital investment and more manpower, or by more effective use of the existing facilities—both equipment and manpower. Productivity is a better way of increasing production—through better utilization of manpower, machinery, power and space. In other words, "productivity includes those techniques which make it possible to increase output without increasing input, of increasing output with a minimum of capital expenditures" (1). The Israel Institute of Productivity charter begins with its avowed purpose to "engage in raising work productivity, improving the quality of products and prevention of waste, improvement of supplies and efficient use of tools" (2). The Institute's objectives were a very big order considering the history and background of industry in Israel.

Up to the Second World War there was only an uneven development of industry, and this small beginning was suddenly expanded by large orders from the British Army. "Workshops became factories almost overnight. This process was accelerated when the State of Israel was established in 1948, and has been continuing ever since. Those who had been able to manage small workplaces soon found themselves unable to cope with the problems created by larger establishments as they had their smaller ones. A few recognised that when a workshop reached a certain size there is not only a quantitative change, but also a qualitative change, which calls for new methods of management, production control, production and distribution" (3). This situation was complicated by an unprecedented population rise from new immigration so that the total population has risen $2\frac{1}{2}$ times in some eight years—new immigrants are still coming into Israel. This population rise has intensified industrial expenses. Then in the first years of the State, most raw materials and almost all machinery and equipment needed had to be imported and paid for with foreign exchange. The raw material and equipment shortages presented managerial nightmares not experienced in the United States in the most austere period of the last war. Israel was faced with the need to make a tremendous expansion in its production and do this with untrained management, new organizations and companies expanding before they could become a team and with a shortage of skilled labor, experienced foremen or industrial engineers. The country needed a spectacular rise in productivity.

To fulfill its objectives the Institute has developed a number of programs that cover the following broad areas: training and education, publishing periodicals and technical material, technical investigations for the government, public forums, discussion groups, and special seminars, demonstration projects and factories, the awarding of scholarships and development of a library service. All these activities have the one objective—to raise productivity, to make the country productivity-minded, and to keep in constant flux productivity ideas.

Training is the biggest activity. In 1955 the Institute ran some 68 organized courses with some 1,600 students attending. The aim of the training is quick results—introduce ideas, give participants a boiled-down course and send them back to the factory to produce. To do this they

[1] The Institute is directed by an eleven-man Directorate composed of the following representatives from sponsoring organizations: Ministry of Labor, 2; Ministry of Commerce and Industry, 2; General Federation of Jewish Labour in Israel (HISTADRUT), 2; Manufacturers' Association, 2; Ministry of Finance, 1; Israel Institute of Technology, 1; Association of Engineers and Architects, 1. The Directorate meets periodically and uses a rotating Chairman. It elects the National Director, not necessarily from this Board.

have developed a simple three-stage system of education, an organized course, followed by a project under supervision, followed by attendance at follow-up meetings. Whenever possible instruction is supplemented with visual aids.

The courses are divided into four areas: Management; Technical Subjects; Cost Accounting; and Office Efficiency. Individual classes run from a 15 hours' introductory course up to a full one year Production Technician's course. As part of the course, the student is expected to complete a practical project using the ideas and techniques he has learned. The project is carried out under supervision of a technical man from the Institute as a consulting engineer. The project, which is on-the-job training, is of great importance. Many of the men taking the courses have been out of school for years and need a great deal of help in putting an organized report down on paper.

As these projects are carried out at work, many result in important improvements in the plant. Recently at a military base a student introduced hanging bed frames on a home made monorail conveyor and increased production by 60%. It is these small important changes that show up nationally in substantial raising of productivity. These are fully publicized in Institute publications, and good case studies are used in the class.

The Institute also gives scholarships to train its personnel overseas in Western Europe or the United States. In 1955 four students were sent overseas. The scholarships are supplied either by the U. N. or the U. S. Technical Aid Program. They have included either attendance at a university or employment in a factory or institution. Both the U. N. and U. S. Technical Assistant staff have supplied personnel who have worked directly in the Institute: for the U. N., Prof. Fish and Dr. Tilles, and for the U. S. Mission, Mr. Bruckart.

A very important activity of the Institute is publishing periodicals and technical literature in Hebrew, making technical information available in the national language. This is of utmost importance to give a common body of technical literature to the country, for there has been very little technical literature in Hebrew which is so needed by those who do not read a foreign language. They publish a monthly *Hamifal*—"The Enterprise"—which always includes several types of articles: an editorial, case studies, features, examples of new techniques from overseas, articles on agriculture and different current articles of the type found in *Factory Management and Maintenance*. They also publish a *Technical Digest* in which are condensations —in Hebrew—of technical and industrial articles from Western publications.

Besides these regular publications, the Institute publishes many pamphlets on special topics directed to a specific audience—either management, foreman or labor. It has printed a very fine and effective illustrated instruction pamphlet for the citrus pickers, who are seasonal agricultural workers, usually new immigrants to the country. They also produce many posters and other visual material in Hebrew.

The Productivity Institute holds many periodic meetings designed to keep contact with people who have taken institute courses, special meetings of topical importance, and conferences designed to serve as aids to specialized groups.

The monthly meetings are of great importance, principally designed to keep contact with those who have already taken an Institute course giving them new ideas and a better understanding of the concepts they have learned. Course participants are individually invited besides being reminded by monthly newspaper advertisements of the meetings. Attendance for all groups in November 1955 was 525 in Tel-Aviv and 360 in Haifa. It is quite an accomplishment to have this steady attendance for topics hardly discussed four years ago, as both cities are small by U. S. standards: Tel-Aviv 400,000 and Haifa 200,000.

In addition to all the above, the Institute holds special seminars or conferences—one shot specialties for people in a particular field. The seminar leaders are often people from the United Nations, the U. S. Technical Aid Program, or the Israel Institute of Technology of Haifa. Three main seminars were held in December, 1955 and January, 1956: a seminar on Human Relations by Dr. R. Eysink of Holland; a seminar on Production Planning and Control by Prof. K. D. Shone of the Royal College of Glasgow; and a seminar on Efficiency in Building by Dr. K. H. Frankel of Sweden.

A standard industrial engineering technique of raising production is through an incentive system, i.e. introducing production standards and paying a premium on production above established standards. When this technique was introduced into Israel, it initially created problems among workers who earned premium pay and found themselves in a higher tax bracket with little net gain. The wage structure in Israel industry is very flat with only a 1.0 to 1.5 spread from bottom to top; the income tax rates were designed by equalitarians and have a very steep progressive income tax; if earnings move up, the Treasury receives a bigger slice. The Knesset (Parliament) authorized that all bonus earnings for production above "normal" will pay a reduced flat income tax rate of 15%, provided a special committee approves the system as rationally founded and accurately carried out. The Productivity Institute was assigned the task of investigating applications for income tax reduction and reporting its findings to the Committee.

The reduction of the income tax on premium earnings increased interest in incentive systems and industrial engineering; these also developed strong pressure from labor to establish standards. Up until the end of 1955 the Committee had 241 applications for approval of new incentive systems.[2] Some of the applications were turned down.

[2] The 241 applications for reduction in income tax on bonus systems from April 24, 1952, to August 31, 1955, are divided into: 72 fully approved; 51 partially approved; 90 rejected; 28 pending. Of those approved, 9405 employees must only pay 15% income tax on their bonus earnings.

They represented arbitrary systems established by agreement from past production, or from inadequate time studies. The whole process has been very useful in making the country productivity minded and has introduced systematic investigation of methods, established standards and a favourable attitude toward productivity not previously found in Israel Industry.

Two side problems have developed from this scheme. Indirect workers and office personnel are generally left out of benefits because of the great expense and difficulty in establishing incentives for such personnel. Many ingenious schemes are being tried out but few have been authorized and there is no generally accepted system found to set standards on indirect or office work. A second problem developed with some manufacturers who had approved systems and did not understand they were to continue making changes in their plants and revise their standards when changes were made. A system of periodic review of approved system had been in the law, but the Institute is only now finding the time and personnel to carry out reinvestigations.

The Institute is now beginning a limited program of work in factories, a plan to simultaneously accomplish several things. First and primarily it is designed to upgrade the Institute's technical staff by giving them real problems to solve. Emphasis is on improving the Institute's technical staff because some of the technical personnel have had limited training and even less experience. The Institute must both train the country and simultaneously upgrade its own personnel, for the technical people often double as instructors in Institute courses. Secondly, the plan functions to raise the productivity of the particular factory and is also used as an example to show other firms how they may improve their operation. The procedure followed has an Institute engineer working as a consultant in a selected company, usually under a senior engineer's guidance.

The Institute's practice of using a technical staff man from a semi-government organization to do practical industrial problems, the writer believes, is a technique that should be applied wherever it can by governmental agencies that have technical staff making audits—engineering, accounting or agriculture. When a professional man is employed by a government agency and only makes audits he becomes stale, only equipped to perform the limited technique of auditing, with professional qualities that are flabby. On the other hand, an engineer who makes technical tax audits, certifies special license for imported goods, or approves use of Governmental money for expansion is far better able to make sound professional judgements if he has kept his hand in at problem solving and knows he is doing real work.

The Institute is also carrying out several major programs of national importance, all now in agriculture. The most important of these is in the citrus industry, Israel's largest earner of foreign exchange. Detailed studies were made of a score of workers in different groves on methods of picking, packing, transportation and handling of oranges. Finally production forms based on time studies were set for various types of groves. The data were so extensive and so well collated and analysed, that at one sitting the results were accepted by both the Association of Grove Owners and the Agricultural Workers' Union. Colorful instructional posters were displayed at all groves. A simple, profusely illustrated brochure on the selected method and containing other aids was printed in three languages (Hebrew, Yiddish and Arabic) and distributed to all the workers. ". . . the industry as a whole hired during the 1952–53 season 7,000 pickers compared with 9,000 hired the season before, and 40 percent more exportable fruit was picked" (4). The Institute still works with the Citrus Industry constantly trying to improve its methods.

The Institute has built up a library of technical books on production, management, office efficiency and industrial engineering. They also have edited and distributed several book lists of recommended books in specific fields. Both of these projects have stimulated reading and purchase of technical books and publications. The American government has been a direct help in the implementation of this program. Israeli booksellers can buy American books at a favourable rate of exchange below the official rate—thus an American subsidy for the purchase of American books.

This, then, is the Institute, a large training program of organized courses, several publications, many meetings and seminars, incentive system audits, demonstration projects in factories and a variety of special services. It has accomplished its first important goal, making Israel and Israelis productivity conscious and rousing interest in production and efficiency.

The Institute now faces a new goal, one that may be much harder to fulfill. It must hold the interest of the country and must now raise the level of its training and its staff.

This next step will be very hard for the Institute and the country, for there is still not the complete understanding of the tremendous work necessary to carry through to completion the extensive plans that are often sketched out so freely on paper.

A typical recent step in carrying out activities at a higher level are two advanced seminars in Industrial Engineering run by the Institute under the leadership of Dr. Kirekhoven of the U. N. With such seminars the Institute is now polishing the personnel needed to manage and direct Israel's new and expanding industries.

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Methods Improvement and the Systems Concept

By P. J. Brown, Jr.

Vice President of Foreign Operations, Scripto, Inc.

As most Industrial Engineers, I feel that there is possibly some misunderstanding of the true nature of Industrial Engineering. Many people, including people in top positions, have the idea that the answer to their problem is to call an industrial engineer and he will furnish for them a pat solution to any problem they have in methods, personnel, organization, or operation. *I simply do not believe this is true.* All that Industrial Engineering training furnishes us is a scientific approach to the solution of problems. It will give us a framework on which to hang a set of facts, *but it in no way eliminates or is supposed to eliminate the necessity for critical and intelligent examination of the fact in light of the whole situation.* Also, no matter how scientific the approach may be, we are dealing with a problem concerning human beings, and scientific solutions quite often do not cover problems in personality, social connections, and group solidarity. I know you have read or seen many times where a perfect paper solution to an operational problem has broken down due to not having considered the social framework of the particular situation.

Before methods improvement can be attempted at all, a great deal of thought must be expended in selection of the operations to be improved, in checking the economic factors involved, and in considering the impact of this change on all functions of the business. The first thing you must do is get a picture of the total operation with which you are concerned. There are possibly many ways to do this. However, in my own mind, *I have designed a concept of a factory as a single tool, and compared it with a punch press which is tooled with several stations.* It is easy then to see that, like a punch press, if all the operations are not working at the same speed and in the proper sequence, you will be limited to the capacity of the slowest component. As a corollary, it becomes apparent that it is extremely wasteful to work on an operation which is already faster than other operations upon which it is dependent. *Your production capacity must always be balanced against the capacity of the slowest component.* If this is not done, you will find that you have built a considerable process inventory of parts which are totally unusable and which will cause considerable investment in storage, warehouse space, and confusion. In my opinion, this is the main reason why cleanliness and good housekeeping in a factory almost always denote an efficient operation. To keep a plant clean, it must be balanced, since it is virtually impossible to keep an unbalanced operation clean.

In order to determine whether a factory is in balance or not, you must have accurate records of machine capacity, labor usage and material. Without these, it is almost impossible to make an intelligent decision as to where your methods improvement work can be best employed.

Assuming that you have selected limiting operations which are most in need of methods improvement, you are then in position to begin analyzing the total situation to determine how far you would go, and how much money can be spent on an improvement. Several factors govern this. First, the character of the business itself. If the business is one which is subject to frequent style changes, the probable frequency of change will of course limit the amount of expenditure, since the time over which the investment can be amortized will be short. The position of your business in the industry is also a determining factor in this calculation. If the business for which you are working is a leader, and therefore more or less controls its own destiny as far as changes are concerned, you would be in a much better position to determine the length of time available accurately. If, however, the business is a small one and is subject in some measure to following the lead of more dominant concerns, it may be necessary to retain much more flexibility.

After having considered the business itself, its nature and objectives, it is necessary also to study the social aspects of the changes you contemplate. To explain what I mean by this—an enterprise always has at least two meanings to its employees. First, it is a means of obtaining economic security. This is perhaps the most important. Second, it is an organization or a group wherein much of the individual's social life is spent, and invariably in all organizations you will find a definite social grouping from job level to job level. The loyalty of the person to the group in which he finds himself must be taken for granted, and must be considered. For some people, their social aspect is considered to be equal to, or more important than, the economic one. The danger lying here is like a hidden reef, in that discontent caused by interference with this social grouping almost always manifests itself in complaints apparently unrelated to the real cause. As an example of this, one company, in order to conserve

space and perform more efficiently, abandoned separate rest rooms for the office workers. From that day on, they were besieged with complaints about supervisors, desks, lighting, coffee breaks, and everything under the shining sun but the real problem—which was simply that the office workers felt that they had lost prestige as a group when the special facilities were abandoned. When these facilities were restored, the complaints subsided.

At this point it may be well to mention the Hawthorne experiments which were performed at the Hawthorne plant of Western Electric Company. These experiments covered a period of over ten years and were conducted by a group of the foremost industrial engineers and educators in this country. The purpose of the experiment was to determine the effect of working conditions, standards, material handling, equipment, and other advancements on a specially selected group which had been picked as an average group for the purpose. Experiments proceeded roughly as follows, holding everything standard except one factor—such as lights. This factor was changed in gradual stages until it was at an agreed optimum efficiency. The group reacted beautifully, and production went up. This same procedure was followed through a series of changes, and each time the group responded as expected. Then, some hard-headed investigators decided that they would prove the findings, so they made the reverse steps—completely reducing and eliminating all the advantages they had given these workers, until they were finally down to barely visible light and no special improvements. To everybody's surprise, the production still held up. From these findings has come a whole new body of information pointing toward the fact that the greater part of the improvements made by this test group was due to the fact that these people had been made to feel important, their work had gained considerable recognition, and they themselves found more satisfaction in their jobs, and in doing them well.

Since that time, a great deal of research has been directed toward determining what actually does motivate people, and some large companies—such as Pennsylvania Bell Telephone Company—have gone so far as to insist that their executives go back to school, not for more technical education, but for a true liberal arts education in order to learn more about the people.

Now, having considered briefly social aspects of business and some of the pitfalls, I think it would be well to understand a little about the principles, advantages and disadvantages of this new word which is a business flag now—"AUTOMATION". Of course, I am laying myself open now for considerable disagreement from a number of people. I have read many definitions of AUTOMATION; what it is, what it will do, etc. For my own part, I like to consider AUTOMATION as a new way of looking at a business. Machinery, electronics, equipment, IBM card systems—all that can be a part of it, but is not in itself AUTOMATION. *In my opinion, AUTOMATION is a concept which says that there is an underlying pattern to any business or any operation, and that this pattern can be controlled and therefore can be mechanized.* . . . Any automatic or automated process handles the routine pattern of business and rejects the unusual. It may have a control device or a feed-back system which will route the unusual for special handling, but it always rejects the unusual. Actually, the advantages are fairly obvious, as there is great reduction in direct labor usually without the corresponding increase of managerial or skilled labor. It makes possible a push-button factory. *It does have, however, some serious limitations.* The severest limitation is that a completely automatic factor is usually non-flexible. It is built for one single job, and if a major change is contemplated, a new factory is needed. A good example of this is the chemical process industries, and particularly refineries. It has long been recognized that it is a difficult job to change the end product of a refinery—and, when radical changes are necessary, a new refinery is necessary; therefore, I predict that with all the publicity now being given AUTOMATION, some factories which are style businesses will wind up by automating themselves out of business. The more astute businessmen are approaching this new phase with caution, and are only making investment in AUTOMATION on those components which after long thinking appear to be fairly stable.

If you have followed through all the steps above and considered all of the factors involved, the economics of methods change are simple. All that is necessary is to calculate the saving accomplished, multiplied by the anticipated life, and measure this against the cost. I think you will find that the procedure followed to arrive at this point, however, will have given you a much better understanding of the business as a whole, and its problems.

If it is decided that a methods improvement is feasible, then comes a job of designing a method, getting it installed and accepted so that it will produce the results which we anticipate. At long last, we have got to the foremen—which is where we were supposed to have started. An industrial engineer needs to realize that some things which seem crystal clear to him with his education, are not nearly so clear to a foreman who has not had that opportunity. He must also understand that some of the social aspects of the problems, and some of the hidden details which the foreman has learned through his experience, may have a great deal of effect on the problem, and may invalidate his whole theory. It is therefore necessary for him to find out why the operation is being done like it is. He can be sure there is some reason for it. *It may not be a good reason, but there is a reason!*

On the other hand, the foreman must realize that the industrial engineer is there to help him, and is not a stranger come to take his job, or is not a smart-aleck who, on the basis of a little college education, has arrived at an easy way to do a job which has taken the foreman many years to learn. He must be open-minded and fair, and must honestly evaluate any suggestion made to him. One of the easiest ways to do this is to make the foreman

and the industrial engineer the same man. This involves considerable training of foremen. They must be taught methods analysis, a certain amount of time study work, and they must be made to practice changes in methods. This is what we have done at Scripto to a large degree.

There is, however, a limitation even to this. It is, of course, common knowledge that constant living with a job makes a person a little bit near-sighted as far as that job is concerned. It is necessary periodically for new people with new viewpoints to study the jobs in order to see what has been missed. It is extremely important, however, that the person who does the studying does it in such a way as to gain the cooperation and help of the foreman, and not his resistance. However, this would vary with various people. *The main point is that the industrial engineer must honestly and sincerely be interested in the person he is trying to help.*

There are a few more cautions I would like to make in setting up methods. Some of these are my own opinions and considerably radical—so I don't expect you to necessarily agree. Let's introduce here another concept. *The only advantage that a worker has over a piece of machinery is the ability to plan and coordinate.* I feel very strongly that any time a worker is required to do a strictly mechanical job—that is, a job that can be performed by a piece of machinery—the person responsible for the job is guilty of sloppy engineering. If, due to various reasons or the nature of the business, it is impossible to mechanize, it is still possible to so set up a job that a person or group of people assigned to it finish with a whole product or a component which has easily recognizable value. In this way, the natural desire of people for accomplishment is satisfied. I have a very good illustration at Scripto of how this works. One of our assembly jobs consisted of five separate sub-assemblies. During the first two years in which we ran this production, these assemblies were kept separate, and the people assigned to them had only to worry about putting a plug in a hole, or attaching a clip to a cap. Work in process was stacked up beside the operations, and rejections were high and causes untraceable. Without changing a fixture, we simply regrouped operations so that a team of five operators with the same fixtures and working interchangeably from operation to operation made a complete finished product. We saved 40% on this operation. *To me, that proves something!*

One other caution in setting up methods. It is extremely important that before a standard is set on any job, the positioning of parts, positioning of tools, and sequence of operations be standardized. Attempting to put a standard on a non-standard job is the rankest kind of foolishness.

Back to the foremen again. Early in the industrialization of this country, a foreman was the top man in a production plant. That is where the term originated. Over a period of years, a centralization of technical services came about. As a result, in quite a few instances the foreman was eventually degraded to a sort of half-worker, half-leader in his department. His methods were set for him and standards were handed him, and he was given the job of making a process work without having any real control of the process itself. I feel that a great many of the grievances, complaints, and serious personnel problems have derived from this. Many complaints which could have been handled by a well-informed and intelligent foreman have, in the process of going uphill to top management, assumed awesome proportions.

Fortunately, the trend now is reversing. One of the examples in this reversal is the story of International Business Machines Company. I recommend the reading of this to anyone interested in a new approach to organization. They have started by upgrading their foremen and have gone so far as to give the foreman his own team of technical experts consisting of mechanical, electrical, industrial, or other engineers who may be necessary to accomplish his mission. This naturally means that the foreman then must be a real executive himself. I honestly feel that if this thing continues, the job of foreman in a well-run plant will become a real executive position, and demand high type personnel.

The question arises—how do you get these foremen, and how do you train them to accept responsibility? There is no one answer. One general principle is sure. Few people readily accept responsibility until it is given them. All I can tell you to do is to give the responsibility to carefully selected people, and make them do it. If, after a period of time, you find they will not accept it, then you must start over. One thing you must always remember. If you have given the responsibility to a man, you must accept some mistakes; and it is a good policy simply to point out those mistakes in such a way as not to offend the person who made them, but to clearly show where the fault lay and what to avoid next time. Just remember that the only one who makes no mistakes is the one who does nothing!

Now that we have belabored the poor foreman for awhile—I have just one or two more things to pass on. *Remember that there are no pat solutions. Your training simply gives you a scientific approach to the problem, and a framework. The solutions will always depend on an intelligent interpretation of your factual data.* Also remember that the most important resource an executive has, and the thing that distinguishes him from a purely technical man, is his possession of what the specialists call conceptual vision. This simply means that he has the capacity to see his operation in its relation to other operations which affect him, or which he affects.

Remember, too, that the most important thing in a manufacturing operation is balance. *An unbalanced operation is always inefficient.* And, finally, never forget that any organization is composed of people. Study the social structure of the organization for which you work, and try to imagine how you would feel in the position of the people affected by your recommendation. The hardest job a young man has to do when starting work for a company is to fit himself into the total structure, and understand why some seemingly foolish thing must be done in order that each individual may keep his human dignity.

Research Problems in Production Routing and Scheduling*

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The main purpose of this paper is to discuss various problems of routing and scheduling, and their interrelationships; and to present one method of attacking these problems. This method is based upon the use of electronic computers to perform simulated experiments, in order to study problems for which direct experimentation is usually impractical or impossible, and for which theoretical investigations have so far yielded few results.

It is apparent that interdependence among various problems of a company is the rule rather than the exception. In particular, the problems of routing and scheduling are strongly related to demands and to the plant's resources, and almost as strongly related to many other factors. However, we shall examine routing and scheduling problems from a comparatively short or medium range point of view, so that such factors can be considered as essentially fixed or as determined outside the production departments. This limitation on the scope of the problems considered here is not, however, essential to the use of simulated experimentation.

Description of the Problems

We shall think of an "item" as a part or an assembly to which certain properties or specifications must be given by the performance of certain operations. The definition of an operation is not intended to include the designation of the machine to perform it, although, of course, the nature of the operation determines limits. Technological factors may determine a definite order of performance for the operations on an item, or there may be alternative sequencing possibilities.

The problems of routing and scheduling are, generally speaking, those of deciding which machines shall perform the operations, and when. The objective is to make these decisions in such a way as to best satisfy some criterion of "goodness." In practice, the criterion is most often at least partly subjective; but in principle it can always be described as the minimization or the maximization of some "optimizer," which takes into account not only direct costs and incomes, but also various less easily specified factors such as the undesirability of failure to meet delivery commitments. We shall not dwell upon the problem of selecting optimizers. It is worth noting that there are advantages to using simple criteria of optimality, but that complicated optimizers offer no real difficulties with the method of simulated experimentation. The use of optimizers is valuable, both because it permits the objective comparison of various possible courses of action, and because the need for defining an optimizer forces management to decide just what its goals are.

As is done in general practice, we separate the problems of routing and scheduling into three main categories, as follows:

1. *Choice of routings.* A routing for a given item is a designation of the types of machines which may perform each of the required operations. It may specify one machine type for each operation, or it may list two or more alternatives.

2. *Choice of lot sizes.* In general, these may vary from one lot to another of the same item. Lot splitting may or may not be allowed.

3. *Choice of scheduling method.* A scheduling method is simply a way of answering questions of the type, "What should this machine be doing now?"

There are a number of interdependences among these categories, and also between them and the actual operation of the manufacturing department. The most important of these seem to be the following.

A. Since many machines are economical only for production runs within certain size ranges, the choice of routings largely determines the choice of lot sizes, and conversely.

B. The choice of routings and lot sizes restricts the choice of schedules, and hence must be considered in choosing a scheduling method.

C. The last relationship implies that scheduling possibilities must be among the primary considerations in choosing routings and lot sizes.

D. In order to be effective in the face of the unpredicted occurrences which are inevitable in actual production, scheduling must be accomplished by a dynamic procedure

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which takes into account the actual situation at the time when the question, "What should this machine be doing now?" is asked. It is this need for a dynamic procedure which prompts us to speak of the choice of a "scheduling method," rather than the choice of a schedule.

These relationships are indicated by Figure 1, which might also include a box labelled "demands," with arrows to all four of the boxes shown—and with arrows from some or all of them, too, if longer range problems were to be considered.

In view of these interdependences, it might seem that it would be theoretically ideal to make all three choices at once. Such an ideal, however, would overlook the continually changing situation in a manufacturing plant, and the frequent need for making routing decisions, at least, well in advance of production, in order to allow time for tooling. Such needs as this make the categories to some extent logical, rather than arbitrary.

Consequently, it is not our intention to try to completely mingle the three general categories of choices, but merely to keep the importance of their interdependence as strongly in mind as possible, while still considering them more or less separately.

Before going on to more detailed discussions of these problems, we pause to indicate why the use of simulated experimentation is suggested, to describe this technique in general terms, and to illustrate its use by a simple example.

Simulated Experimentation

As will be indicated below, current practice in dealing with the problems of routing and scheduling often seems inadequate. On the other hand, the results of mathematical and theoretical investigation have been very limited. Consequently, it is natural to turn to experimentation. But direct experimentation is largely impractical. In the first place, the costs potentially involved limit experiments to slight variations of methods which have been tested in practice. More important, the value of the experimentation which can be performed is greatly reduced by the lack of controls and the practical impossibility of replication. Modern statistical methods can help to resolve these difficulties; but the slowness with which data can be collected, as well as the major year-to-year changes in aspects of production outside the problems of routing and scheduling, makes it very unlikely that even the most subtle statistical analysis will permit practical resolution of these problems by direct experimentation alone.

Thus we are led to simulated experimentation, a technique which has been used successfully to solve many problems of business and of the military. This technique is similar to the engineering method of building a model and testing its performance, and is closely parallel to the modern practice of testing an engineering design by studying the behavior of an electronic analog.

The first step toward simulated experimentation with production problems is to construct a conceptual model which represents the manufacturing plant and the work

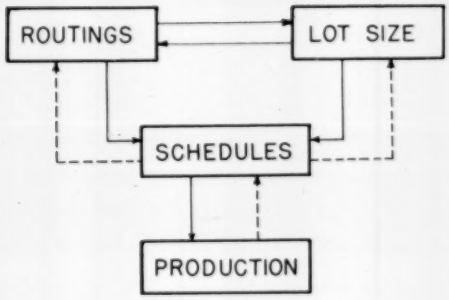

FIG. 1

to be done, in arithmetical and logical terms. This model may be very simple, omitting many details of the actual situation and idealizing the rest, or it may be extremely complex, just as the models used by aircraft designers vary from miniature representations of external surfaces to complete realizations of the design under consideration. The complexity of the model depends upon the problems to be studied. Since the problems of routing and scheduling are concerned with detailed occurrences within a plant, appropriate models are generally somewhat complex.

The second step is to program a computer, human or electronic, to simulate the operation of the plant, by "operating" the model. The complexity of the problems of routing and scheduling requires the use of high speed electronic computers to simulate any but the simplest practical problems. However, it will be most convenient here to present in detail a hand computing arrangement for a very small and artificial illustrative problem. Computer engineers will have no difficulty in seeing how this model can be enlarged and generalized, and programmed for electronic computation.

An Example of Simulated Experimentation

As an illustration, we consider a grossly simplified problem, since space does not permit adequate description of a model sufficiently complex to be of direct practical value.

Three jobs, J-1, J-2, and J-3, are to be processed by a plant having machines M-1, M-2, and M-3. The sequence of operations on each job is completely determined; fixed routings have been decided upon in advance; it has been decided that each job is to be processed as a single lot; lot splitting is not allowed; and we even assume that the exact processing time which will be required for each operation is known. These data, along with data related to the scheduling methods to be considered, are given in Table 1.

Each job is "available" for its first operation at time 0, and for each subsequent operation at the moment when the preceding operation is completed. A job can be assigned to the machine designated for a given operation at the time when it becomes available for the operation, or at

TABLE 1

Job-Cards for the Illustrative Example

Job	Operation Numbers	Machines	Required Times (days)	Priority Numbers	
				Method 1	Method 2
J-1	J-1-1	M-1	3	10	7
	J-1-2	M-3	5	7	2
	J-1-3	M-2	2	2	0
J-2	J-2-1	M-1	6	11	5
	J-2-2	M-2	2	5	3
	J-2-3	M-3	3	3	0
J-3	J-3-1	M-2	5	9	4
	J-3-2	M-3	4	4	0

any later time. It is required that a machine work whenever work is available for it, but a machine can work on at most one job at a time. The time needed for transportation is assumed to be negligible, and the possibility of machine breakdown is excluded from the model.

We have listed these assumptions in full detail to indicate how explicitly the conditions of a problem should be defined before a conceptual model can be used. There is no theoretical limit to the complexities which can be put into such a model, but no detail can be expected to appear unless it is explicitly put in; and care must be taken that unnoticed limitations are not implicitly included in the model. Several unrealistic characteristics have been included in the illustrative example, for the sake of simplicity.

The problem is to determine which of two methods of scheduling will result in the completion of all three jobs by the earlier date. The assumptions listed above imply that a schedule will be completely determined if a way is given to decide which of a number of jobs will be assigned to a machine "next," whenever a conflict arises. "Scheduling Method 1" requires that the job be assigned for which the total remaining processing time is greatest; while "Scheduling Method 2" requires the assignment of the job for which the remaining processing time, excluding that for the operation under consideration, is greatest.

The model is based upon a Gantt chart; that is, a chart with bars which can be filled in to indicate what each machine is scheduled to be doing at each moment in time. The restrictions on filling out this chart are: (1) Each operation must be assigned an interval of length equal to its processing time, on the bar representing the machine designated for it by the routing. (2) The intervals assigned to a single job must not overlap, and must be in the required sequence. (3) The intervals assigned to different operations on the same machine must not overlap.

The model actually consists of the chart, along with the stated restrictions on the way it can be used.

We now describe the computational arrangement for this problem. Each job is represented by a "job-card," on which is recorded the job's relevant data. These cards list the required operations in the required sequence, the designated machines, the processing times, and the "priority numbers" to be used for each of the two methods of scheduling. The data for these cards is given in Table 1.

The priority numbers are computed by adding appropriate processing times. For instance, the priority number of J-1-1 under Method 1 is the sum, $3 + 5 + 2 = 10$, of the processing times for J-1-1, J-1-2, and J-1-3; and the priority number of J-1-1 under Method 2 is the sum, $5 + 2 = 7$, of the processing times for J-1-2 and J-1-3. In each scheduling method, the decision as to which job to assign "next" is made by choosing that one which has the largest priority number for the operation concerned.

Each machine is represented for the computation by two boxes: an "on-box," which at any moment in the computation contains the card representing the job on which the machine is "working," if any; and an "available-box," which contains cards representing jobs which are available to the machine.

The computation is a repetitious step-by-step procedure, starting with Step 1, and continuing until all job-cards have been discarded. At this time, the Gantt chart represents the schedule resulting from the scheduling method used in the computation. The computation procedure is as follows, Step 1 being given separately because it differs in detail from the others.

1-A. Place each job-card in the available-box of the machine designated for its first operation.

1-B. For each machine whose available-box contains one or more cards:
   a. Remove the card with highest priority number for the first operation.
   b. Make a check mark beside the first operation number.
   c. Indicate on the Gantt chart bar corresponding to the machine an interval starting at 0, and of length equal to the processing time for the operation.
   d. Place the card in the on-box of the machine.

1-C. Proceed "in time" across the Gantt chart, until the end of one or more of the indicated intervals is reached. Let this be "time" T_2.

n-A, $n \geq 2$. For each machine whose last indicated interval ends at T_n, move the job-card in the on-box to the available-box of the machine designated for the first *unchecked* operation on the card; if all operations are checked, discard the job-card.

n-B. For each machine whose on-box is empty and whose available-box contains one or more cards:
   a. Remove the card with the highest priority number *for the first unchecked operation.*
   b. Make a check mark beside this first unchecked operation.
   c. Indicate on the Gantt chart bar corresponding to the machine an interval starting at T_n, and of length equal to the processing time for this operation.
   d. Place the card in the on-box of the machine.

n-C. Proceed "in time" across the Gantt chart from T_n, until the end of one or more of the indicated intervals is reached. Let this be "time" T_{n+1}.

The results of computations using Scheduling Methods 1 and 2 are exhibited in Figure 2, where it is seen that Method 2 results in the earlier completion of the three jobs.

We now return to the discussion of practical problems arising in choosing routings, lot sizes, and scheduling methods.

Choice of Routings

The most obvious way to choose routings is to assign each operation to the machine which can perform it at least cost. In general, this machine can be determined only after the lot size has been decided upon, but in most situations, this is not an important practical difficulty, because the order of magnitude of the lot size for a given item is usually determined by the nature of the demand for the item.

A more serious difficulty is that assigning each operation to the minimum cost machine is very likely to overload certain key machines, thereby creating bottle-necks. Where the demands on the plant are homogeneous with respect to time, this will occur only if the plant's facilities are poorly chosen in relation to these demands; but in a large proportion of manufacturing, the continual variation of amount and of the nature of demands makes unequal loading of machines unavoidable if minimum cost routing is used in an inflexible way. Thus, it is necessary to consider scheduling possibilities in order to obtain the best routings.

Overloading can be reduced by the use of alternative routings. Decisions must be made as to when alternatives will be necessary, which alternatives are to be used, and what operations are to be assigned to them. If time is important, the last two questions must often be answered well in advance, so that proper tools and fixtures will be available when needed. In most plants, rule of thumb methods are used, and they often appear to be reasonably successful; but the arbitrariness of these methods suggests that there is room for improvement. Linear programming techniques have been developed recently for handling these problems under various conditions, and have been successfully applied by a number of manufacturers. We shall not give the details of these techniques here, since they are well described elsewhere (1).

The choice of routings has other effects on scheduling possibilities, which are more subtle than those describable in terms of machine loads. In particular, it often occurs that the backlog of a certain machine suddenly grows, creating a temporary bottleneck, even when total loading is well levelled from machine to machine. This, as well as other occurrences which seem almost to be the result of happenstance in the present stage of knowledge, raises problems in plant operation which require further research. Simulated experimentation has not yet been used, to the authors' knowledge, to study these problems, but some of the incidental results of work directly concerned with other problems indicate that this technique can be effectively applied to them.

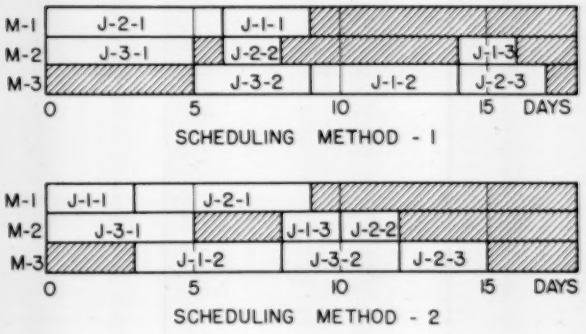

FIG. 2

Choice of Lot Sizes

In some job shops, lot sizes are essentially determined by customer orders; but if any items, even individual parts, are produced "to stock," or if it is necessary to produce large orders in several lots, then the question of lot size determination arises.

One approach to this problem is the economic lot size method, according to which lot sizes are chosen so as to minimize the sum of setup costs and inventory carrying costs (2). This method does not take scheduling possibilities into consideration; and it is perhaps largely for this reason that intuitive and rule of thumb methods are used by most manufacturers.

Roughly speaking, the advantages with relation to scheduling of small lots include shorter flow times, smaller in-process inventory, comparative flexibility in scheduling, and less need for lot splitting. On the other hand, large lots tend to result in higher machine utilization (unless scheduling difficulties arise), permit smaller percentage overage allowances for scrap, and simplify the dispatching function. Extremely large lots, of course, also permit the use of highly efficient automatic and semiautomatic machines.

It is conceivable that these effects can be taken into account quantitatively, by a method similar to the economic lot size method, but applicable to a wider class of production situations. The problem of developing such a method seems suited to investigation by simulated experimentation, and some preliminary steps have been taken toward designing appropriate experiments.

Choice of a Scheduling Method

Detail scheduling—that is, the assigning of specific jobs to specific machines at specific times—is presently accomplished in many plants by very haphazard procedures, which sometimes seem reasonably effective, but which often amount to little more than a continual

scramble to meet commitments. Such procedures are in use because of the need, in making decisions, to take into account the actual situation at the time the decisions are made. This need, with the inevitability of unpredicted occurrences, makes it infeasible to follow detailed schedules determined in advance. A workable scheduling method must be dynamic, in the sense of adjusting itself to unexpected circumstances.

Most of the systematic scheduling methods proposed in the past have failed because they have lacked this dynamic characteristic. However, since it is widely felt that current scheduling methods are often inadequate, there is strong motivation for research in this area.

Analytic treatment of detail scheduling has been effective in certain cases concerned with semicontinuous or batch process manufacturing (1). These are cases in which the determination of routings and lot sizes fixes the essential details of the schedule, although not necessarily the specific time at which each operation is to be carried out.

On the other hand, theoretical and mathematical research directed toward the problems of detail scheduling which typically arise in job shop production has so far yielded no results which are applicable except under very rigid and unrealistic assumptions (3) (4).

Thus, we are again led to the use of simulated experimentation. This technique has been applied by the Management Sciences Research Project to a number of problems concerned with the comparison and evaluation of systematic methods for scheduling job shop production. This work started with the design of a generalized model, to represent situations typical in certain shops. Both manual and electric routines for "operating" this model were then developed. Various specific problems were expressed within the framework of the generalized model, and computations were carried out to compare the efficacies of various scheduling methods with respect to these problems. The examples studied so far have not been full scale industrial problems, but have been research problems designed to be typical of those arising in job shops which produce to customer order, and where lot sizes are essentially determined by demands.

One of the most important difficulties of scheduling, that concerned with unpredicted occurrences, was included in the problems by allowing for statistical variation from predicted times of the "actual" times required for operations. In terms of the illustrative example, this means that the lengths of the intervals indicated on the Gantt chart were not predetermined, but were to be chosen from probability distributions by a random process. Corresponding to the usual practice in the particular plants on which the generalized model was based, alternative routings were not considered, nor was lot splitting allowed.

Most of the problems studied were concerned with scheduling to meet given due-date requirements. The problems were designed in such a way that it would not be easy to achieve the desired goals.

As in the illustrative example, the basic scheduling problem considered is that of deciding which of several jobs should be assigned to a given machine "next." The methods studied are based upon the idea of making such decisions by comparing "priority numbers" similar to those used in the illustrative example. These priority numbers are computed from variables among those which seem to be most relevant to the decisions to be made; and there is in general a different priority number for each operation. Because the priority numbers are functions of "scheduling variables," this type of method is called "priority function scheduling."

The specific purpose of the experimentation performed so far has been to evaluate the relative importances of different variables, and to determine priority functions which are effective in terms of the criterion of meeting the required due-dates.

Among the simple functions which proved to be of particular interest are those of the form

$$D - ap + bq;$$

where D is the due-date of the job, p is the total predicted processing time for the remaining operations on the job; q is the predicted processing time for the operation under consideration; and a and b are positive constants of the order of magnitude of unity. Values of b close to unity have generally given the best results. It was found that values of a as large as 3.5 often resulted in the best schedules when the effect of statistical variation from predicted operation times was small, but that values between 1 and 2 were most satisfactory when large variations occurred.

These preliminary results can be rationalized by noting that when $a = 1$ and $b = 0$, we have $D - p$, the amount of future waiting-time the job can be permitted and still finish on time. Increasing the constant a tends both: (1) to decrease this permissible waiting time to account for the fact that the flow time of jobs through a machine is ordinarily substantially greater than the actual processing time required; and (2) to give preference to jobs at one machine whose completion will release a large amount of work to other machines. Increasing b tends to give preference to jobs which will not tie up the machine under consideration for a long period of time. The change in the best value of a with increasing statistical variation in machining times is not surprising when it is viewed as a change which gives decreasing credence to the quantity q as the reliability of that quantity decreases.

The effect of the degree of statistical uncertainty on the best choice of the constants suggests that the best scheduling method varies with the accuracy of predictions of relevant variables. This in turn suggests the use of simulated experimentation to study the problem of data accuracy requirements and to determine the advantages with respect to scheduling to be gained by improved work measurement methods. Preliminary steps have been taken toward the design of experiments for this purpose.

Conclusion

Simulated experimentation has begun to prove itself as a valuable tool for basic research on problems of production routing and scheduling, even though the work on scheduling methods outlined above is still in an early stage, and only preliminary steps have been taken toward the use of this tool for the investigation of the other problems discussed in this paper. The use of high speed electronic computers for simulation, which is getting under way at the time of writing, can be expected to increase greatly the usefulness of simulated experimentation for basic research in production routing and scheduling.

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Quality Planning and Control

By Frank M. Gryna, Jr.

Assistant Professor of Statistical Quality Control, Rutgers University

Quality problems are usually attacked by making an investigation of the process to find out why the man, material, or machine is causing bad work. These technical investigations sometimes fail to yield a solution because the underlying trouble is much deeper than a process difficulty. We have already developed important statistical tools that help immensely in process investigations. We now need a broader management analysis of the quality problem.

When referring to the quality problem, we talk of "quality control". Management people do not talk of "control" but rather "planning and control". This article is basically a list of the elements and techniques of planning and control as applied to the quality function. (No attempt has been made to list all of the possible techniques.) If this list is reasonably complete and correct, it may be significant in a practical way. To those who already have a quality program, this list can be helpful in evaluating the completeness of the program. To those who are now installing a program, the list can help to set up a broad program for quality improvement.

Planning

The planning phase of the quality job should include:

Planning Element 1: Realistic Specifications

It would be pleasant to be able to assume that all specifications are set on a realistic basis. This is simply not the case. Some specifications are set by rule of thumb methods that are based on custom and conservative guesses. But just what is a realistic specification? Just one that is set with consideration of the functional needs of the part and also the capabilities of the process. We all agree to the logic of this concept. The trouble is that we fail to get the facts that would ensure realism.

Technique: As a basic solution, we must furnish the design engineering function with numerical estimates of the capabilities of the various processes. Process capability studies (as mentioned later) will provide this data. If a capable process is not available, then a review of the functional needs is in order.

Today, however, few design engineers are supplied with process capability data. This forces them to issue specifications based on functional needs alone. If the functional needs are not precisely known, then the only resort is custom or a conservative guess. This means that if you suspect a specification will be difficult for a process to meet, it is reasonable to point this out to the design function and review the basis on which the specification was set. Questioning the specification should be the first step in attacking a quality problem. Imagine what this means. Entire quality problems can be (and have been) solved by just investigating the basis of a tolerance. A questioning attitude is necessary toward tolerances—even at the expense of some raised eyebrows.

Planning Element 2: Specifications That Are Clearly Stated

A. Dimensional. An operator surely cannot be expected to meet a specification that is stated in vague terms. Juran (1) suggests a neat criterion: "The specification should define the characteristics of the product in such a way that possession of the specification alone is sufficient to convey to the prospective manufacturer the design engineer's concept of what is wanted."

Technique: Luckily for us, most specifications can be stated in numbers. However, if the specification cannot be expressed numerically, then a series of physical standards may have to be issued to define the limits of acceptability.

B. Allowable per cent defective. To expect a quality level of 0% defective would be the acme of naiveness. Even if 0% defective was attainable, the total cost would be astronomical. However, there apparently are a few good reasons why it would not be wise to have a quality level of 100% defective. Somewhere in between, there is a "most economical level of quality". You and I agree to the logic of this, but we just don't bother to get the facts to use the concept—or rather, we say that it is not feasible to get the facts to calculate the most economical level of quality.

Technique: A study must be made to find out the level of quality that the production people should regard as their objective. You might well ask at this point: "Isn't the required quality level stated by the customer?" Yes, but we must operate at the level that yields the *minimum total cost*. For example, suppose a customer specifies 3%. It may be cheaper to produce at a usual quality level of say 4% and then sort out some bad pieces rather than make a fundamental change in the process. Let's hope that such an instance is rare, but I mention it only to emphasize that production should aim at a quality level that results in the lowest *total* cost.

Notwithstanding the forlorn moans of our accounting friends ("Young man, how many years of free time do

you have available for this study?"), it is definitely possible to collect the necessary data. The key is to realize that only approximate costs are necessary. We only wish to know whether the estimate of the most economical level of quality is significantly different from the current per cent defective. Again the significance of this technique lies in the fact that it alone can solve a quality "problem". A plant may be struggling to reduce a quality level from 3% to 2% when a study may show the most economical level to be about 4%.

Planning Element 3: Operating Procedures That Are Capable of Meeting the Desired Quality Level

A. The machine

1. The machine assigned to the job must be capable of meeting the specification. All of us accept this but, as before, we fail to gather the necessary facts.

Technique: Process capability studies give a quantitative measure of the amount of variation that must be expected from a process. For example, a study might conclude with the statement: "This process is capable of meeting a tolerance of ±.002". (Such studies first check to see if the process is operating at its best.) Experience in statistical quality control has shown that it is not reasonable to assume the current performance of a process represents its true capability. Once this investigation is made, then a statistically valid estimate of process capability is determined. This number indicates the minimum variation to be expected under practical operating conditions. Why don't we supply design engineers with a "handbook" of process capability data? Some companies are now working on this.

2. The machine must be kept capable. Under the pressure of more immediate problems, it is natural that we tend to minimize machine maintenance until repairs are absolutely necessary. By the time all parties agree that the repair is absolutely necessary, many defectives may have resulted.

Technique: The fundamental answer is a strong systematic maintenance program. The short run policy of "fix it when it breaks down" must be questioned to see if the losses due to wear and breakdown—and the quality loss is just one—justify a preventive maintenance program.

Preventive maintenance is a key step toward the *prevention* of defectives.

B. The man

1. The man assigned to the job must be capable. Sometimes this item alone can be a most perplexing cause of serious quality problems on all products. The new plant or the plant with high labor turnover is certainly in a poor position.

Technique: Here, we must take operator capabilities and experience into account when assigning jobs. But how about the problem of having no operator with sufficient experience or training to handle a particular job? If the pressures of production force us to economize on training time, then at least management must acknowledge that a comparatively poor level of quality is to be expected. When such a problem is plantwide, then it is time for management to reconsider the comparative importance of training time and the pressures for production.

2. The man must be instilled with a positive desire to meet the specification (or stop the machine and seek help when defectives are made). My position may tempt you to regard this point as academic. Juran (2), a management consultant with heavy industrial experience in quality control, says: "The operator must feel that it is to his personal advantage to regulate the process to achieve good quality. In the author's opinion, this is the crux of the problem." The average worker today does not have the same pride of workmanship that was characteristic of the craftsman of yesteryear. Incentive systems sometimes promote operator attention to quantity at the expense of a proper regard for quality. Unfortunate indeed are those plants that have incentive systems that pay for both good and bad work. (Alas, some plants even pay *premium* pay for bad work!) If your own quality problems seem difficult, walk through a plant that pays for bad work and notice the attitude of the operators toward the quality of the pieces and the efficient utilization of raw material. Quite a discouraging picture.

Technique: An answer is "only pay for good work." In addition to being simple, this answer is not practical. We must qualify it to the extent that an operator be paid for bad work that was caused by conditions beyond his control. This can lead to problems because it is sometimes difficult to agree on who or what caused a defective piece. The benefit of the doubt is given to the operator. In some cases, these doubtful instances set precedents for the future and before long the company pays for most bad work.

A more positive approach is to sell "quality mindedness" to the operator (and everyone else). When skillfully discussed, the appeal to pride of workmanship can be effective in promoting a strong regard for quality. The emphasis on the relation between quality of work and job security can be even more effective. Though still limited in development and application, the incorporation of a quality bonus into a quantity incentive system has great potential. Finally, a penalty for bad work is sometimes effective. This usually takes the form of a bad piece being returned to the operator to repair on his own time. The problem of placing the responsibility for the defective again arises here.

C. The material

1. The material must be functionally adequate. In actual practice, the administration of this principle may pose some problems. For example, should a specification on raw material be regarded as rigid, and if not, who can change the specification?

Technique: As a fundamental policy, no changes or modifications in a specification should be allowed without the approval of the design engineering function. Testing should take place when the capabilities of a material are

not known. Specifications set on new material should be denoted as preliminary or tentative and should be reviewed when experience is available. A modification of a specification (in the light of actual experience) may enable the purchasing function to achieve large savings in material costs.

2. The material must be inspected before it is released for fabrication. Practice differs widely here. Some plants have little incoming inspection, some inspect for quantity but not quality, and many inspect for both quantity and quality on a 100% basis.

Technique: In most cases, 100% inspection is not justified. A statistically designed (not "common sense") sampling plan serves the purpose. Published tables are available. The Acceptable Quality Level for the sampling plan must be set in a realistic manner. (I am happy to be now able to cite a reference (3) that provides a realistic quantitative method for setting the Acceptable Quality Level. If you are faced with the important problem of setting an A.Q.L., be sure to read this reference.)

Control

The control phase of the quality job should include:

Control Element 1: A Realistic Amount of Inspection with the Results Reported in Useful Form

A. *Inspection for the purpose of informing the operator of his actual performance so he can properly regulate the process.*

We would hardly think of comparing actual golf performance to the specification (par) without keeping a scorecard. Yet we are weak in informing the operator of his quality performance. The operator can depend upon hearing about a batch of bad work but many of us fail to supply him with a continuous record of his performance so that he can anticipate trouble and adjust the process before any defectives are made.

Technique: A system of continually informing the operator of his current performance is necessary. Inspection can be made by the operator and/or a patrol inspector. This is the spot where graphical charts have proven so successful in actual practice. A quality control manager once told me: "All I have to do to reduce the per cent defective on a product is to post a control chart on the floor." Of course he meant this as an exaggeration, but he cites examples of immediate quality improvements once a chart is posted and *before any engineering investigations are made.* The reasons for this may be twofold: (1) the chart signifies that management is vitally interested in the quality of the product; (2) the chart serves as a simple scoreboard that promotes a new interest in quality and makes it easy to evaluate the effect of adjustments in the process.

B. *Inspection for the purpose of accepting or rejecting the product and to provide the facts for the overall guidance of the quality program.*

The case for sampling plans is clearcut—they reduce costs. (There are other tangible advantages but cost reduction will suffice here.) For those who maintain 100% inspection in order to "avoid the risks of sampling", we can only point out that a wide variety of industries report that 100% inspection is often not 100% accurate in finding defective pieces.

In addition to the job of "sort the good from the bad", the inspection function must report the results in a useful form. Specifically, this means in a form that will help *prevent* the manufacture of more defectives.

Technique: The amount of inspection is really a question of whether or not to use a sampling plan rather than 100% inspection. When the answer is "Yes", the published sampling tables will furnish plans for the great majority of cases.

The problem of useful inspection data is twofold: content and form. To help prevent defectives, inspection data must include the *reasons* for rejection and the corresponding quantities and dollar values to show the relative importance of the reasons. The largest part of quality problems is usually caused by only a few reasons for rejection. Inspection reports must make it apparent which are the quality characteristics that are the basic troublemakers. This will help insure that quality efforts are concentrated where really needed, instead of spread more or less equally among all quality characteristics. (A good way to be sure that the predominant troublemakers are known is to provide weekly and/or monthly summaries of the daily reports. Most of us get hopelessly lost in a mass of detailed reports and find it difficult to extract the fundamental meaning of such reports.)

In deciding on the form of such reports, graphs can be of utmost value. The ability of graphs to summarize data and highlight important information makes them amazingly helpful in getting action. Words cannot convince the uninitiated of such a nebulous concept, but a simple trial will be pleasantly surprising. Take the daily inspection reports for one month; summarize them by making a simple vertical bar graph. Now compare the meaning of the graph to the meaning of the mass of detailed reports. As another example, a running graph which shows the daily per cent defective for a department or entire plant can yield good results with little effort.

Control Element 2: Staff Activity that Analyzes Inspection Reports and Customer Complaints to Make Recommendations for Guiding Overall Company Efforts on the Quality Problem.

Inspection reports the facts on quality, but someone must evaluate the facts, make recommendations, and coordinate the overall quality program.

Technique: This is the job of a "Quality Planning and Control" function. The immediate problem here may be to convince management of the justification for such a function. The best way to do this is to compute the total dollar amount of current quality losses (cost of defectives,

rework, manufacturing waste, customer complaints, etc.). Juran estimates this loss to be between $500 and $1,000 per productive worker per year. If such figures do not result in a higher priority to the quality problem, then we can only conclude that other company problems must be in a horrible state of affairs.

Control Element 3: Staff Activity That Can Help the Production Function to Find and Correct the Causes of Bad Work

Production has the basic responsibility to see that the parts are made correctly, but the supervisor simply does not have the time to solve the more complex quality problems. The underlying causes of bad work don't walk up to the foreman's desk and ask to be corrected. Planned production experiments requiring full time engineering effort are often needed.

Technique: This would be part of the job of "Quality Planning and Control." The staff quality function must be available (when requested) to help find and correct the causes of bad work. Quality engineers can apply the new techniques of the design and analysis of production experiments. New techniques such as these require specialized advanced training that we could not expect a foreman to possess or obtain.

Feedback—Key to Planning and Control

The real key to planning and control is the feedback phase—the flow of information on performance back to the planning phase where it can help in future planning. Unfortunately, we all assume that feedback automatically occurs and take too few specific steps to insure it.

There are techniques for achieving feedback. Inspection reports are the primary feedback in the quality function. Customer complaints are a part of feedback. The feedback phase can also include verbal participation (in the planning phase) of all parties concerned with the quality problem. For example, a committee to review the design and manufacturing plans for important new products can serve to achieve feedback. Such a committee might have representatives from design, manufacturing, industrial engineering, inspection, purchasing, and sales. Theoretically, all this could be handled through a series of memorandums, but "sitting down together at the same table" promotes better attention to the problem and certainly makes it easier to question and discuss any doubtful procedures. The aim of such meetings would be to *prevent* defectives by giving each function the opportunity to hear and point out any bad effects of the plans of other functions. Would a social organization start the year's activities without first having an executive meeting where the various committeemen present their own plans for review by the whole group?

The Correct Title is "Quality Planning and Control"

Look back at the listing of elements and notice that the larger portion of the discussion is devoted to the planning phase. Yet we never formally speak of "quality planning". This is probably due to the disagreement (even in management circles) on the meaning of the word "control". The word is now almost meaningless (4). This is not an academic matter because some people define planning as one part of control. The failure to recognize that these are two separate phases of management has led to an underemphasis of the need for planning. We abound in "quality *control*" activities (inspection, making recommendations, and helping to correct trouble). Do we devote enough efforts to "quality *planning*"? After all, the better the job we do on planning, the less the job necessary on control. An idealistic statement, but I propose it as a fundamental thought to have you reconsider the division of your efforts between planning and control. The quality problem is *not* basically different from other company problems and therefore it is subject to the fundamental principles of management.

REFERENCES

(1) J. M. JURAN (Editor), *Quality Control Handbook*, New York, McGraw-Hill Publishing Co., 1951, p. 50. (This book is a good reference for details on many of the techniques mentioned in this article.)

(2) JURAN, *op. cit.*, p. 269.

(3) JOHN W. ENELL, "Which Sampling Plan Shall I Choose", *Industrial Quality Control*, Vol. X, No. 6, May 1954, pp. 96–100.

(4) The important distinction between planning and control was pointed out to me by Dr. Alex W. Rathe of New York University. He suggests the word "review" instead of "control".

Teaching Position

Handle Industrial Management major in small college. Teach 12 hours including "Industrial Management" course; other courses depending on training, experience and preference. Outside consulting allowed. Rank and salary according to degrees and experience. Minimum instructor $4000, assistant professor $4500, associate professor $5000—no top. Engineering degrees preferred; industrial engineering experience essential. *Send resume to* PROF. R. L. WILLARD, Chairman Division Career Studies, Utica College of Syracuse University, Utica, New York.

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RECENT READABLES

AUTOMATION

"Computer System Specifies Correct Grinding Wheel Formulas", *The Iron Age*, Pg. 84, January 12, 1956.

The day of computer controlled production may not be too far off. . . . Already punched cards representing customer orders are integrated and coordinated by computing equipment. Human error is eliminated right down to the production foreman level. Orders directly from the field arrive on perforated tape and are fed into an electronic machine that calculates the correct grinding wheel formulation, calls out raw materials necessary, specifies manufacturing instructions and schedules delivery dates.

"Data Processing by Electronics", by Haskins and Sells, 67 Broad Street, New York 4, N. Y., 113 pp., free.

With the development of electronic data-processing systems, a new and valuable tool has been added to plant management's bag of tricks. The authors have attempted in this little book to follow a middle road—to give the interested reader who is not a specialist in the subject a basic understanding of the operation and use of electronic data-processing systems. Beginning with a comparison of various methods for data processing—manual operation, key-driven operation, punched-card system, and finally, electronic systems—the book goes on to describe the scope of electronic data processing, fundamentals of programming, preparing for the electronic system, basic theory, systems components, and techniques. Finally, the appendix gives the operating characteristics and costs of equipment.

"What Computers Can Do For You", M. G. Melden, *Factory Management and Maintenance*, Pg. 99, February, 1956.

A special report by the Associate Editor of *Factory* relating what computers are available today, what they can do, what future problems they will be solving, how to get started with them, and how they will affect your operations and organization. Examples are given of what computers are doing now; where computer service can be obtained; and how to organize to make ready for the new era.

GENERAL

"Labor Looks at Industrial Engineering", O. Lasser, *Advanced Management*, Pg. 14, January, 1956.

Is labor irrevocably against time study? Incentive systems? Increased automation and production? The author holds that it is not, provided that the basic aspirations of workers should be indispensable parts of the programs which the engineers develop. He hopes that "engineers will become more rather than less involved with labor problems and that they should come to occupy positions of responsibility in this field" and believes that "the engineer who considers all the human and social implications of his proposals may more likely succeed in the long run." This article is based on a paper presented by the author before the S.A.M. Central Pennsylvania Chapter in November, 1955.

"Scientific Management in Hospital Administration", V. D. Schoeller and G. J. Anyon, *Advanced Management*, Pg. 22, January, 1956.

Pointing up our hospitals' financial and personnel problems, the authors demonstrate that hospital administrations are in a very advantageous position to use scientific management principles because of the basic high motivation of their employees and the constant capacity utilization of their facilities. They discuss hospital administration areas in which improvements can be made, and recommend the development of people skilled in both scientific management and the solution of hospital problems, indicating that S.A.M.'s civic affairs work has been an important step in this direction.

INCENTIVES

"New Kind of Quality Incentives", R. T. Dingman, *Factory Management and Maintenance*, Pg. 126, January, 1956.

A unique technique developed by the Wincharger Corporation seems to disprove the old theory that you can't ask for higher quality without losing productivity. This new quality incentive system, which is superimposed upon the regular production incentive system has reduced defects by two-thirds along with a small productivity increase of 5 per cent. The basic theory is this:

As long as quality is kept within limits, the output of a production crew is just sample-inspected. This partial inspection requires only one inspector. But when quality gets out of line, additional inspectors—usually two or more—are called in and all work is 100% inspected. And—here's where the quality incentive comes in—the crew must absorb the cost of this extra inspection time. It is charged against the crew's production incentive earnings.

INVENTORY CONTROL

"A Pegboard Inventory System", J. Hockman, *The Office*, Pg. 69, December, 1955.

One of the problems of keeping stock records is the volume of paperwork involved. Electronic or punched card methods are ways of reducing the manhours required, but the volume of stock record work is often a problem in offices where the overall volume makes it difficult to justify elaborate equipment. The author describes a way to consolidate the records and handle the data in bulk instead of by individual postings. By using composite summary records instead of individual ledger cards for separate items, the clerical manpower needed is greatly reduced, the work can be checked for accuracy as it progresses and close control of stocks is provided.

JOB EVALUATION

"Why Use Job Evaluation", C. R. McCullough, *Petroleum Processing*, Pg. 1899, December, 1955.

Describes the efforts of how a major petroleum company set up a job evaluation system. The system was designed to: (1) Establish a relative value for jobs both within and between departments; (2) Permit comparison of pay rates with similar jobs in other companies; (3) Permit management to recognize significant changes in the duties and responsibilities of a job; (4) Show which job changes constituted promotions and which did not.

After an evaluation of the four types of job evaluation systems, the factor comparison system was chosen. A discussion of the six factors used along with the advantages of the new system is given.

MATERIALS HANDLING

"Five More Transfer Tricks for Overhead Conveyors", *Modern Materials Handling*, Pg. 86, February, 1956.

The January issue of *Modern Materials Handling* described seven transfer techniques for overhead conveyors which described some of the basic systems used to move loads on and off trolley conveyors automatically. The issue presents additional techniques involving movements between overhead conveyors and belts, chutes, fixed stations, and other overhead conveyors. They include a wide range of layouts, costs, rates of output, and, in particular, types of loads carried—bags, metal chairs, foundry sprue, cartons, castings.

"Memory Device Controls Push Button Sorting", J. Joseph, *Modern Materials Handling*, Pg. 78, December, 1955.

A new segregation system that dispatches packages to selected points automatically by means of push buttons on a central control panel is used for sorting incoming materiel at an Army Air Force Base. The system daily dispatches about 50,000 lb. of supplies in odd lots to repair, storage, or redistribution areas.

The key to the unit is a memory device which controls sorting on a slat conveyor equipped with from six to a dozen air-actuated push-off blades, which move packages from the slat conveyor to lateral roller conveyors at right angles. Packages are dispatched automatically to pre-selected lateral lines, and transferred to them by the remotely controlled push-off units.

"Materials Handling", by Editors, *The Iron Age*, Pg. 170, January 5, 1956.

This article presents a forecast for 1956. The trends in material handling equipment are forecast to be as follows: (1) More tailored continuous handling systems made up of standard equipment; (2) Sturdier lifting equipment will elevate heavier loads higher than ever before; (3) Expect more compact, versatile and speedier conveying equipment for manufacturing line use; and (4) Scrap handling systems will become more available, more standard, less costly.

"What Makes Yard Handling Click", F. C. Wier, *Modern Materials Handling*, Pg. 106, February, 1956.

A 20 per cent increase in production has been realized at Timken Roller Company. This has been possible because of a flexible yard handling system organized and controlled to serve the needs of production with a high degree of efficiency. Underlying the system are concepts that in some cases are completely at variance with commonly accepted ideas of good practice in materials handling. The reason for this is that the major objective of the plant handling organization is not to obtain lower handling costs, but rather to provide a materials movement service to all production departments. To provide free movement, full flexibility and complete reliability, Timken's system includes the following features: superior housekeeping; equipment in depth; pool operation; centralized radio dispatching; good maintenance; trained drivers; alert supervisors; operator performance reports; equipment cost records; and streamlined paperwork.

"Balancing Movement with Accumulating Conveyors", E. H. Woodberay, *Modern Materials Handling*, Pg. 94, February, 1956.

Automatic accumulating conveyors can provide industry with an invaluable tool for integrating and controlling the flow of materials during processing and storage. They can be designed for almost any condition or operation—from the highly automated production line to job shop departments and plants. The article discussed gravity roller, gravity wheel, chute, live, semi-live, roller slat, ripple belt, cascade, belt, vibrating, power and free and special conveyors. The functions and uses of these conveyors as accumulators is discussed.

PLANT LAYOUT

"How to Plan Layouts", by Editors, *Modern Materials Handling*, Pg. 84, September, 1955.

"While the ideal procedure when making a plant layout is to first establish the handling system and then build the plant around it, ordinarily the plant is already built and machines and assembly lines must be spotted within the confines of existing walls and columns. This complicates the problem and often requires compromising the best layout.

Yet, if the same techniques were used to plan layouts for old plants as are used when designing new facilities, many of these problems could be minimized, handling costs lowered, and production rates increased. The major steps involved—18 in all—fall under three major headings: Pre-planning the Operations, Making the Layout, and Checking the Results."

PRODUCTION CONTROL

"Controlling Piecework Production", F. Bardach, *The Office*, Pg. 70, February, 1956.

A good piecework system must provide proper records of the work done for the calculation of earnings. Hand in hand with the system goes a well organized production control procedure. After each operation has been analyzed as to when, where and how to be done, operation charts are made to list materials, tools, methods, standards and other pertinent information. Various routing and reporting procedures are discussed and illustrated.

SCHEDULING

"Mechanizing Paperwork for Preventive Maintenance", W. H. Kearns, *Factory Management and Maintenance*, Pg. 142, February, 1956.

Relates how one aircraft company set up automatic controls to assure necessary inspections and repair services. The installation of a machine-scheduling method for preventive maintenance work has virtually eliminated errors, guesswork, and needless counting. The system is stated to be quite simple. Once set up, it requires only five forms, including a permanent machine record and machine history file for 1800 machines. Pencil work has been minimized throughout—with only one full-time maintenance planner and two clerks for 500 maintenance workers.

WORK SAMPLING

"Corning Engineers Check on Selves", A. J. Agett and W. D. Walker, *Plant Engineering*, Pg. 122, February, 1956.

Describes how Corning's Industrial Engineering Department decided to apply work sampling to its own operations to control and reduce costs. The results of the study indicated how to improve office operations with very little time and effort. Each engineer kept an account of just how much time he spent on each phase of his activity each day. In addition, records were kept of units of work accomplished, such as number of Position Descriptions, Job Evaluations, Incentive Rates, etc. Savings were achieved in organization charting, wage and hour law reviews and office clerks. A few high level executives are now using work sampling as a means for self-analysis and improvement.

Job Evaluation, E. Lanham, McGraw-Hill Book Co., 330 West 42nd St., New York 36, New York, 404 pgs., $6.00.

Uses a practical and down-to-earth approach to explain the steps that must be performed in installing and maintaining a job-evaluation program, how these steps should be carried out, and who should be responsible for doing so. Not only outlines the desirable current techniques, but also discusses the philosophy behind each. Particularly interesting is the chapter on the role of organized labor in job evaluation.

Successful Production Planning and Control, American Management Association, 1515 Broadway, New York 36, New York, 202 pgs., $5.50 ($4.00 to members).

Covers the subject from forecast to final delivery. Several chapters each under these major headings: Organizing for Maximum Results, Factors in a Successful Program, Groups and Individuals That Should Contribute, Company Programs and Approaches. Most of the material is based on a special conference on production forecasting, planning and control held by the AMA's Manufacturing Division.

Dimensional Motion Times—Development and Application, published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, New York, 100 pgs., $4.00.

For some time, people in industry have been using the stopwatch method for motion-time study. Now, claims the author, there is another method to supplement the first one and replace it in some types of operations. This system uses the dimension of production parts and determines operational times synthetically.

The method reported in this book is based on considerable study which includes laboratory work. Through the handling of parts that were closely dimensioned, differences in grasp times were noted as thicknesses of objects varied. Positioning times also were observed. In practice, this system is applicable to repetitive production operations in which work conditions are controlled. It is not recommended on maintenance jobs or where conditions vary appreciably such as may be the case in job shops.

The publication contains tables of times and gives examples showing the use of chart figures. Some of the subjects considered are: need for Dimensional Approach; DMT training requirements; motion classifications, codes and descriptions; effect of contour irregularities on grasping time; and steps for analyzing production methods.

Profit Sharing for Small Business, by J. J. Jehring, Profit Sharing Research Foundation, Evanston, Illinois, 53 pgs., $1.00.

Although this booklet was written especially for the owners of small businesses, the information it contains should be of interest and help to all plant executives interested in the profit-sharing idea. The study is based on information gathered from 78 small businesses that have been practising various forms of profit sharing for a number of years.

Describes the benefits of a successful program, such as better employee relations, increased production, lower employee turnover, and the like. Gives specific information that will help you answer at least most of the questions that will enter your mind. Samples: just what profit should you share, how are the profits to be divided among employees, what employees should you cover, how often should you distribute profits, should you allow your employee to withdraw money from the plan without leaving your employ, should employees be allowed to borrow against the fund, where to get help in installing your plan.

Includes specific data and operating ratios for many successful plans; and a checklist for designing a deferred profit-sharing trust plan.

Office Automation, by R. H. Brown, Automation Consultants, Inc., 1450 Broadway, New York 18, New York, 301 pgs., $12.50.

A non-technical work on integrated and electronic data processing. It covers the commercial aspects and existing applications, equipment, automatic accounting, sociological aspects of automation and potential applications. There are no circuit diagrams or formulas, but there is a scientific section on Operations Research.

RESEARCH REPORTS FROM THE MANAGEMENT SCIENCES RESEARCH PROJECT, UNIVERSITY OF CALIFORNIA, LOS ANGELES

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The following listing supplements the listing published in the January-February issue.

Research Reports which are no longer in print

No. 9 (See *Pacific Journal of Mathematics*, vol. 4 (1954), pp. 29–36.)

No. 28

No. 31 (See *Econometrica*, vol. 21 (1953), p. 480.)

No. 32 (See *Proceedings of the American Mathematical Society*, vol. 4 (1953), pp. 429–430.)

New Research Reports

No. 44 "A Computing Procedure for a Line Balancing Problem," J. R. Jackson, 1955, 20 pp.

A systematic enumeration procedure for the solution of a problem in production line balancing is presented, and illustrated by solving an example. A brief indication is given of the procedure's mathematical justification. Questions of the general efficiency of the procedure are not answered, but work with experimental problems indicates that hand computation will be feasible for many practical problems.

No. 45 "The Additivity of Universal Standard Data Elements," E. S. Buffa, 1955, 18 pp.

A summary and evaluation of past research pertinent to the hypothesis of additivity of universal standard data elements. It is shown that this hypothesis has not been adequately tested. Experimental procedures are proposed for testing the hypothesis.

No. 46 "Research Problems in Production Routing and Scheduling," A. J. Rowe and J. R. Jackson, 1955, 14 pp.

The interdependence of the problems of choosing routings, lot sizes, and scheduling methods is discussed, and it is suggested that these problems be studied by the use of electronic computers to perform simulated experiments. The application to this technique is described in general, and an illustrative example is given. Specific problems are discussed, and research to date concerning scheduling methods is outlined.

A condensation is published in this issue of the JOURNAL.

No. 47 "Process Analysis of the Iron and Steel Industry: A Model," T. Fabian, 1955.

A linear programming framework is presented for predicting the capacity of the iron and steel industry to produce various mixes of final products. It is pointed out how this framework can be used as a starting point for the development of models representing various production planning problems in an integrated steel mill.

Discussion Papers

All Discussion Papers are out of print. However: the material of No. 19 is largely contained in Research Reports 11 and 24; the material of No. 21 and 26 is largely contained in Research Report 34; for No. 48, see *Journal of Industrial Engineering*, Nov.–Dec., 1955; the material of No. 52 is contained in Research Report 46.

INSTITUTE INTERESTS

ATLANTA CHAPTER

The application to business and industry of "operations research", which has been so successfully used by the armed forces in solving the problems of combat and of research, was discussed by engineers and scientists from all parts of the country at an all-day meeting in the Georgia Tech Architecture Auditorium, Friday, February 24th.

Sponsored by the Atlanta Chapter of the American Institute of Industrial Engineers and the Georgia Tech School of Industrial Engineering, the meeting made available to representatives of Southern industry the latest techniques of "operations research".

After a welcome from Howard P. Emerson, vice-president of AIIE and Professor Frank F. Groseclose of Georgia Tech, the morning session was opened by a paper on "Operations Research —A Challenge to Management" by J. W. Pocock, Booz, Allen & Hamilton, management consultants of Chicago, Illinois. This was followed by papers on "Linear Programming" by Robert O. Ferguson, Vice President, Methods Engineering Council of Pittsburgh, Pennsylvania, and on "Queueing Theory" by Dr. W. R. Van Voorhis, Professor of Mathematics of Case Institute of Technology, Cleveland, Ohio.

The afternoon session opened with a talk by James W. Thompson, Chief Industrial Engineer, Argus Cameras, Inc., Ann Arbor, Michigan, on "The Industrial Engineer Uses Operations Research". A former instructor of physics at Georgia Tech and now systems analyst to the Union Switch and Signal Division of Westinghouse Air Brake Company, Pittsburgh, Pennsylvania, Dr. Frank B. Brown, discussed "An Industrial Case History in Operations Research".

Following a banquet in the evening at the Elk's Club, Peachtree and Fowler Streets, at which Frank J. Johnson, President of the Atlanta Chapter of AIIE, was toastmaster, Dr. C. A. Slocum, Director of Operations Research Institute, New York, New York, talked on "Preparing for the Future in Operations Research".

BATON ROUGE CHAPTER

The Baton Rouge, Louisiana Chapter held its January dinner meeting at Mike and Tony's.

The guest speaker was Mr. Joseph C. Nickels, Assistant Chief Industrial Engineer of the Post Office Department. His topic was, "Applications of Industrial Engineering in the Post Office Department," and it was extremely enlightening to learn the progress that has been made in this area. Mr. Nickels used "before and after" slides to emphasize the changes that have been made so far.

Mr. Nickels was among friends, as the Chapter had invited the various Post Masters in the state and Post Office representatives of nearby areas.

At the February meeting, we were very fortunate in having Colonel Frank Groseclose, past AIIE National President and head of the Industrial Engineering Department at Georgia Tech, as our speaker. His topic was "Automation" and it was well received by both members and guests. He pointed out that it was important to keep a balance between advanced Automation and industrial workers. By using examples, he showed how it was not wise to allow Automation to take the place of the workers. The laying off of workers as a result of installing automatic machinery might lead to hardship later on when it becomes necessary to enlarge the workforce to meet increased product demand.

Colonel Groseclose was accompanied by Mrs. Groseclose, and during their visit they were given the opportunity to see a little of Baton Rouge. Colonel Groseclose visited some of the local industries and was guest of honor at a luncheon attended by the chapter officers and a group of local industrial leaders. Mrs. Groseclose was guest of honor at a luncheon attended by the wives of the chapter members.

BOSTON CHAPTER

A seminar on the Work Factor System for predetermining time standards was sponsored by the Boston Chapter of AIIE.

Consisting of five sessions beginning on Tuesday evening, March 27, the seminar was designed to better acquaint local engineers with the Work Factor System, according to William J. Vallette, president of the Boston chapter of AIIE.

Discussions were under the leadership of George H. Martin, industrial engineer, Standards Section CBS-Hytron, who had been authorized by the Work Factor company to discuss all phases of the system.

In addition to five demonstrations, sessions covered such topics as Degrees of Motion Difficulties, Standard Elements of Work, and Simple and Complex Assembly.

CLEVELAND CHAPTER

The February meeting of the Cleveland Chapter was held on February 2 in the Terminal Room of the Hotel Cleveland. Mr. Robert Walker of Walker and Van Haelen, Inc., Management Consultants, spoke on "Office Supervisory Training Through Work Measurement".

This was an opportunity to hear a former associate of the Paul B. Mulligan and Company speak on a new concept of supervisory training in the office via work measurement. With the presentation of case histories on this subject, we all benefited from his experience.

The March meeting of the Cleveland Chapter was held on March 1 in the Midland Building. The subject was "Memo-Motion Study—A New Industrial Engineering Technique"—a new practical and economical photographic technique for analyzing operational methods and establishing time standards.

This meeting was a Lab session where typical problems through case histories were presented on film. Actual equipment necessary to take memo-motion studies was on display.

Mr. Robert Blair, President of Production on Films, Inc., gave a short introductory talk on memo-motion study technique prior to showing the films. His firm has done much in aiding the growth and acceptance of memo-motion study since its development in 1945 by M. E. Mundel.

An informal panel consisted of:

Bill Lynam—Case Institute of Technology
Roy Rix—Cleveland Electric Illuminating Company
Bob Walker—Walker & Van Haelen Associates

The above members of the informal panel have had first-hand experience with memo-motion study.

DALLAS—FORT WORTH CHAPTER

The officers elected at the January meeting were installed at a dinner in Fort Worth at the Cattlemen's Cafe. The new officers for the forthcoming year are: President, A. L. Ziegelmeyer, Jr., Pangburn Company, Fort Worth, Texas; Vice President, R. H. Lundberg, Chance Vought Aircraft Corporation, Dallas, Texas; Secretary, Allen W. McCoy, Fritz W. Glitsch & Sons, Inc., Dallas, Texas; Treasurer, Roger W. Palmer, Chance Vought Aircraft Corporation, Dallas, Texas.

About 55 persons attended the meeting. Following the installation, Mr. Jim Coburn of Consolidated Vultee Aircraft Corporation in Fort Worth presented a program on quality control.

The Dallas-Fort Worth Chapter held their second annual management forum on March 20, 1956, at the Statler-Hilton Hotel in Dallas. Activities began with registration at 9:15 A.M. and continued through a morning of talks to a noon luncheon and afternoon of panels and discussions. The day's activities were closed by a social hour and dinner.

The program committee gathered an impressive array of talent to cover the day's talks which included Improving Management Effectiveness, Planning for Growth, Increased Profits Through Proper Production Planning, Results Through Management Control, Solving Management Problems in Small Plants, and a panel discussion on Cost Reduction Programs—More for Your Money.

DAYTON CHAPTER

A meeting of the Dayton Chapter was held on February 21 on the UD Campus. The subject was "Electronics in Work Measurement".

For the first time this year our program subject was in the specific area of Time and Motion Study. We were fortunate in securing Dr. Gerald Nadler, Professor and Head of the Industrial Engineering Department, Washington University, St. Louis.

Following is a brief summary of the topic: "Devices utilizing electronic principles are being designed to determine accurate and precise answers in many measurement fields. Measuring (rating) operator performance is still one of the most difficult and controversial measurement problems in engineering. The development of the UNOPAR to measure accurately velocity, acceleration, distance, time, etc., of human motions, promises to give precise knowledge of basic motion activity and operator performance to help solve the rating and other motion and time study problems."

The March meeting was held on March 13 in the Standard Register Company Auditorium. The subject was "The Use of the Learning Curve as a Production Planning Tool".

The meeting presented to the industrial engineer a practical, useful and relatively little known technique for application in production planning and estimating labor costs. For this program, we were able to obtain the services of an authority, Mr. Hal Horton, Supervisor of Scheduling, North American Aviation, Columbus, Ohio.

The learning curve theory is a well known phenomenon, i.e., reduction of labor costs occurs largely due to the learning ability of workers to reduce the working time on repetitive operations. Mr. Horton presented the theory, basic relationships and examples, with emphasis on the latter to illustrate how you can employ the technique.

ERIE CHAPTER

The Erie Chapter (#51) of the AIIE received its charter at a dinner meeting October 12, 1955. The meeting was held at the Saga Club in Erie, Pennsylvania. Professor W. G. Stanton, Founder of the AIIE, presented the charter to Chapter President Paul J. Murray. Also present was Mr. M. A. Payne, the Director of Chapter Expansion. Local dignitaries included Arthur Gardner, Mayor of Erie, F. G. Brinig, Vice-President of the Erie Manufacturers' Association, the Reverend W. G. Nash, Dean of Gannon College and I. H. Kochel, Administrative Head of Penn State University Behrend Center.

An interesting sidelight was the fact that the charter presentation was recorded by television movie camera and televised over Station WICU. We are told that this is the first chapter to have its charter presentation on T.V.!

Our Program Committee has planned a series of fine presentations for this year. Our Membership Committee is planning a recruiting drive, and our Public Service Committee has lined up several worthwhile projects to utilize the abilities of the group. We are hopeful that the Erie Chapter will soon attract all I.E.'s in the area.

LOUISVILLE CHAPTER

Mr. Bleick Von Bleicken, founder and general manager of the Institute of Modern Management, delivered a very worth-while talk before the Chapter Membership at its regular January meeting. His subject was: "Predictability of Human Behavior". His talk pointed out the folly of the assumption that all people react alike. He made the suggestion that we study and determine what to expect in the way of human behavior from each person; that groups do not ordinarily respond as we might predict, especially with an appeal to logic and reason.

The February meeting was held on February 15 at the Kentucky Hotel. Mr. Charles Winkelman, Management Consultant from Middletown, Ohio, spoke on "Let's Be Objective about Wage Incentives".

Mr. Winkelman is well known for his very excellent presentation. His programs always present the most original and practical approach to real problems in industry.

Mr. John M. Farnbacher, Vice-President of the AIIE Central Region, was in Louisville on April 18 to address the local AIIE chapter. His topic dealt with policies, objectives, and other items of interest from National Headquarters. The question and answer period following Mr. Farnbacher's talk enabled Louisville members to get in closer touch with the ideas and views of our National organization.

The Louisville Engineering and Scientific Societies Council has for some years presented an annual banquet during the month of May. The Council consists of some twenty local chapters or sections of national societies, such as: American Society of Civil Engineers (ASCE), American Society of Metals (ASM), American Society of Mechanical Engineers (ASME), American Society of Tool Engineers (ASTE); Kentucky Society of Professional Engineers, and American Institute of Industrial Engineers (AIIE).

Each year one of the member societies is designated to sponsor this annual banquet. This year, 1955-56, the Louisville Chapter of AIIE will be the sponsor.

The program for this ninth annual banquet, to be held at the Brown Hotel on May 10th will consist of:

Dinner.

Presentation of Awards to two outstanding engineering students of the University of Louisville.

An address by Arthur Breise. This discussion will concentrate on the humorous aspects of industrial engineering and will be designed to appeal to the ladies, as about one-third of the expected total attendance of 450 persons will consist of women.

PENINSULA CHAPTER

The regular monthly meeting of the Peninsula Chapter was held on February 14, in Crothers Memorial Hall, Stanford University. Mr. C. S. Selby, Production Coordinator for the Hewlett-Packard Company, was the speaker. His subject was "Some Factors in the Design and Evaluation of Packaging for the Industrial User".

Inasmuch as the Industrial Engineer is often called upon to help evaluate or design the manufacturer's shipping containers,

the subject was most appropriate. The speaker pointed out the relationship of packaging to the over-all material handling operation, and broke down packaging into its three basic elements: Preservation, packaging, and packing.

Mr. Selby is a graduate of the University of Denver, with the degree of Bachelor of Science in Physics. His present position with Hewlett-Packard involves primarily the over-all supervision of the assembly departments, and as an appendage to this he has assisted in designing his company's shipping containers, a project which he enjoyed to the point of describing it as "fun". Mr. Selby is past chairman of the Society of Industrial Packaging and Material Handling Engineers.

SAN FRANCISCO-OAKLAND CHAPTER

On January 5, Professor Bruce G. McCauley gave an excellent talk entitled, "Effective Time Standards Result in Cost Reduction and Control." Professor McCauley is a member of this chapter and is on the faculty of the University of California in Berkeley.

He gave a case study report on the Alameda Naval Air Station industrial engineering program, on which he has been a consultant for the past two and one-half years. This program has been concerned with establishing methods and setting up standards, which is part of the Navy's overall Management improvement Program.

J. E. Brooks, one of our own AIIE members from the Peninsula Chapter, gave a very interesting talk on the growth of the electronics industry in the San Francisco Bay area, and on the importance which industrial engineering is playing in this industry. Mr. Brooks is currently manager of the Industrial Engineering Department at Lenkurt Electric Company, San Carlos, California. He told of the problems which were faced by the industrial engineers who initiated the industrial engineering program several years ago. From the start they have had to justify their activity by showing actual savings.

The San Francisco-Oakland Chapter and the Peninsula Chapter worked together this year to put on a Western Regional Conference which was held April 6 and 7 in San Francisco. The theme of the conference was "Engineered Standards for Profit."

There were a variety of interesting exhibits displayed by commercial firms and public institutions. The conference had a program of speakers selected from throughout the United States who are top notch in their field. It was a very successful conference.

Jack Frost, a member and past president of this chapter, has been working on a very unique program of industrial engineering participation in the Junior Achievement groups. The objectives of this program are: (1) to familiarize the members of these groups with the real meaning of industrial engineering, (2) to stimulate an interest and a following in the profession, (3) to demonstrate the principle that increased productivity at less cost means more jobs, and more goods and services for everyone, (4) to illustrate a few basic I.E. approaches to solving a typical J.A. production problem.

Jack has already developed visual aids. He went to Seattle in February in order to meet with the leaders of J.A. and to work out a concrete program if possible. It is hoped that this program will spread and become national in scope with full support by the AIIE.

ST. LOUIS CHAPTER

The February Chapter Meeting was held at the Town Hall Restaurant. After an excellent dinner Mr. Floyd W. Simerson of the Sears, Roebuck Company spoke on the "Philosophy, Benefits and Pitfalls of Work Simplification." Two noteworthy announcements were also made to the group at this meeting.

1. The one-hundredth member was introduced to the membership.

2. The St. Louis Chapter shall institute a program for promoting the development and improvement of its members in the field of Industrial Engineering. The Professional Relations Committee was assigned the task of developing this program and shall give consideration to the establishment of an annual Achievement Award to be granted to a chapter member for outstanding accomplishments in the field of Industrial Engineering during the year.

St. Louis Chapter members are looking forward to the May Dinner Dance. This final meeting of the season will bend from the traditional professional proceedings of our monthly meetings when chapter members and wives will wine, dine and dance.

Chapter members as well as St. Louis citizens now have a chance to further their Industrial Engineering education in their homes with the establishment of a television course entitled, "Work Simplification." This course, offered by Washington University through Television Station KETC, Channel 9, claims a "television first" as the first engineering course ever presented on television. Our own Dr. Gerry Nadler, Professor and Chairman of the Department of Industrial Engineering, Washington University, presides over these weekly Monday evening broadcasts, lecturing and demonstrating the techniques of work simplification via video.

A Motion & Time Study Course, offered by the Department of Industrial Engineering of Washington University at St. Louis, will be presented from June 6th through June 15th. This course is intended for personnel desiring a basic introduction to Motion and Time Study. Material covered will be presented with emphasis on setting up correct methods before work is in existence, as well as on techniques for the improvement of existing methods and procedures.

This course is being presented with the cooperation of the St. Louis Chapters of the American Institute of Industrial Engineers and the Society for Advancement of Management. For further information concerning course content, instructors, and registration, write to the Department of Industrial Engineering, Washington University, St. Louis 5, Missouri.

WINSTON-SALEM CHAPTER

The annual Motion and Time Study Conference sponsored jointly with the Greensboro Chapter of S.A.M. was held January 20 with 205 in attendance.

The first speaker at the morning session was J. G. Gilland, manager of the Factory Accounting Division of Studebaker-Packard Corporation who spoke on "The Application of Measured Daywork to Production Line Manufacture".

Following Mr. Gilland, the conferees heard a talk by Mr. Mohe H. Solworth, President, Industrial Sanitation Counselors, Louisville, on the subject "Work Standards in Cleaning and Janitor Service".

Reitzel Morgan, President of the Greensboro Chapter of S.A.M. presided at the morning session.

Joseph T. Watts, President of the Winston-Salem Chapter of AIIE called the afternoon session to order and presented Mr. Steve Hamlin, who is associated with Ernst and Ernst, Certified Public Accountants, New York. Mr. Hamlin spoke on "Controlling Maintenance Cost".

The concluding speaker for the afternoon session was Mr. George H. Gustat, Director of the Industrial Engineering Division at the Kodak Park Works, Eastman Kodak Company. Mr. Gustat spoke on "The Use of the Motion Picture Camera in Motion and Time Study".

R. W. Grupenhof, National Director of the Greensboro Chapter of S.A.M. presided at the evening session following the banquet. The speaker for the evening was Mr. W. W. Taylor of Uhling, Taylor and Associates of Cincinnati. Mr. Taylor spoke on "Method Incentives".

An international note was added to the conference by the pres-

(Continued on page 134)

READER COMMENTS

Applicability of Standard Data for Production Scheduling

The content of Mr. Alan J. Rowe's article in the November–December issue of the JOURNAL came as a surprise in light of the title. The source of this reaction is Mr. Rowe's obvious neglect of a problem apparently more important than the one of additivity he discusses in determining the applicability of standard data to production scheduling. Also evident were some notable misconceptions.

It may be inferred from a number of statements in the article that the term "standard data" means to the author what is commonly referred to as the predetermined motion time technique, microscopic standard data, etc. In the comments that follow I have assumed this same connotation. However, the term "standard data" is used more commonly to refer jointly to the microscopic (motions) and macroscopic (time study elements) forms of the technique, or to the macroscopic form alone.

One misconception concerns the nature of standard data commonly in use. The author correctly implies in his second paragraph that conventional time standards and the parent standard data are intended to represent a common and arbitrary level of effort. He summarizes this by saying, "Thus, a basic standard can be defined as one which represents a norm of performance rather than actual performance."[1] But in the next sentence he goes on to say, ". . . the actual average time which is spent performing a given task would approach the standard in the long run." This is an erroneous impression. It is common practice to set a standard with the intent that it *may be exceeded* on the average by a comfortable margin. But more important, it is a common experience to find these standards *actually exceeded* by widely varying amounts. And this latter result is to be expected in view of differences in ability and level of exertion among operators. In fact, the situation might be viewed with suspicion if actuals agreed with standards as stated above.

Returning to the conventional type of time standard, how satisfactory an estimate does this standard provide for planning and scheduling purposes where we are interested in predictions of *actual performances that will be exhibited* by individuals or groups of individuals on their respective operations? The conventional time standard is an estimate of the performance we *should* get, yet the appropriate time to use for production scheduling is an estimate of what we *will* get. The error involved here apparently has not been established; however, the ordinary spread of operator "efficiencies" in plants provides an indication that it certainly exceeds the two or three per cent stated by the author as justification for neglect of a source of error.

In the next paragraph Mr. Rowe states: "Standard data is a compilation of the actual average times for performing particular elements of work."[2] Later in the article the author brings up the question of the suitability of using these average actual time values as bases for predicting performances of individuals. He answers the question by saying, "Presumably, selection procedures in industry provide a reasonably homogeneous population so that the use of averages is suitable." Yet selection procedures commonly used in industry are still of the informal and subjective type capable of admitting persons differing considerably in ability. Moreover, ability is not the only determinant of differences in performance; motivational differences also play an important role. Therefore I see no justification for passing this off a priori, as a matter of negligible error. At present there is just as much justification for the opinion that standard data based upon average actual times will yield a sizable expected error when used as a predictor of the actual performance of particular individuals or subgroups of individuals. This is based upon knowledge of the spread that can be found in operator "efficiencies" even within departments. Otherwise, why incur the added expense of obtaining an average if the population is so homogeneous that negligible error results in predicting the performance of a particular individual of that population from the mean? It is likely that the resulting error is greater than the two or three per cent mentioned by the author, and that it overshadows the error discussed at length later in the article: the error due to non-additivity.

Standard data is more suitable when standards representing a common level of effort are desired. In this case the desired standard is independent of the operator subsequently assigned to the operation, so that the synthetic nature of times originating from standard data is not a disadvantage. This same synthetic feature makes standard data less suitable when we desire prediction of a time that

[1] This type of time value, obtained through the rating process, is popular because of the wage incentive and cost control functions of time standards.

[2] This too is a misconception, for although it is a possibility, it is not customary. Standard data is conventionally based on rated, not actual, times.

WILEY BOOKS

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By H. C. Geppinger, General Electric Company. In this pioneering work, H. C. Geppinger makes available a new systematic method of work measurement based on dimensional factors. His book provides you with clear, concise terms for specifying and recording work details by motions and for predetermining the necessary manual time of operations. Like other modern synthetic time systems, it replaces cumbersome stop-watch methods—eliminating the controversial procedure of "performance rating"; offering greater flexibility in meeting component changes; promoting standardization; and facilitating training programs.

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As described in this book, DMT is positive, self-contained. Familiarity with decimal equivalents and the ability to read blue prints are the only requirements for an understanding of the technique. 1955. 100 pages. $4.00.

INDUSTRIAL WAGE AND SALARY CONTROL

By Robert W. Gilmour, Ford Motor Company. Behind this book lies one of the most intensive studies ever made of the job analysis and evaluation programs of some of America's largest and most diversified companies. Using the findings of this study, the author discusses the application of advanced techniques in the important area of wage and salary control. The book gives the most detailed treatment available anywhere of the point evaluation plan—the system which has had widest acceptance in industry. Detailed, practical information is given on the development, installation, and administration of the system. It is backed up at all points by examples drawn from actual industrial experience; a twenty-five-job sample demonstrates the operation of the system.

A feature of the work is its clear treatment of the statistical aspects of job analysis and wage control. The methods given are suited to both large and small companies and the directions are complete—to the point of giving the most effective presentation of wage and salary plans to top management. Recent developments in automation and the guaranteed annual wage are considered in detail. 1956. 261 pages. $7.50.

LEGAL PROBLEMS IN ENGINEERING

By Melvin Nord, Consultant in Law, formerly of Wayne University. Written by an engineer who is also a practicing lawyer, this book is designed for use and reference by engineers and to serve as a guide for engineering students. It deals with almost every legal subject that has any bearing on engineering, and its treatment of each topic is deep and thorough.

A special feature of the work is its treatment of case material. Instead of following the usual, voluminous "case-book" approach, the book uses its cases to illustrate the discussion and to point up the legal problems which may be encountered in given circumstances. There is a minimum of legal jargon. Detailed documentary examples, like specifications, have been eliminated. Further savings in space have been made possible through the author's de-emphasis of economics. Although economic aspects are never discounted entirely, this is a book on legal problems, and the emphasis is placed very properly on law. 1956. 391 pages. $7.50. *Textbook edition also available to schools and colleges.*

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is dependent upon the particular operator(s) assigned to the job, and yet this is the kind of time that is appropriate for planning and scheduling.

The content of a number of recent articles and papers has indicated that some writers are confusing two distinct types of correlation problems related to standard data. Mr. Rowe has performed a service in making clear this distinction through his sensible discussion of the "statistical dependence" and "additivity" problems. This is exactly what the article is, however, a discussion of correlation as related to standard data. It is not an analysis of the applicability of standard data to production scheduling as the title and introduction to the article imply. This choice of title and introduction is unfortunate for it has made the author vulnerable to criticism for omission of a number of important factors that should be considered in determining the applicability of standard data.

Edward V. Krick

Author's Comments

The problem of determining the applicability of standard data can be divided into two areas:

1. Is standard data a theoretically sound procedure, whether applied at the microscopic or macroscopic level?

2. What are the requirements for time estimates to be suitable for predictive purposes in production scheduling?

The paper entitled "Applicability of Standard Data for Production Scheduling" emphasized the former problem; that is, are we dealing with a correct procedure. The intent was not to compare time study standards vs. standard data, nor to discuss which was more applicable for production scheduling. The scope of the paper was delineated so as to consider in detail one of the major objections which has been raised concerning the applicability of standard data, namely the principle of additivity. The paper merely indicated what some of the other requirements were, without going into detail. It might be desirable to write a separate paper comparing other means of arriving at time estimates other than the use of standard data. Therefore, the basic question posed in the paper is not one of whether other methods are preferable to standard data, but rather is standard data itself suitable for predictive purposes and estimating time requirements.

As was indicated in the paper, standard data is currently being used for estimating completion time. The qualifications of reliability and validity were discussed. It was pointed out that a basic standard could be defined as one which represents a *norm* of performance, rather than *actual* performance—further that the norm should be attainable by qualified workers and that although the standard would not precisely predict *individual* performance time, that the actual average time would approach the standard in the long run. For standard data to be suitable for predictive purposes, the norm should represent average performance of a group. In particular, since it is a well known fact that performance of individuals follows a frequency distribution, it seems rather naive to attempt to predict a single value other than the mean of the distribution. I think that the point of confusion is the difference between total daily production and performance during the time that the operator is actually working. Presumably, allowances form the basis for the statement by Mr. Krick that the standards are *expected* to be exceeded by a comfortable margin.

As far as the wide variations in performance are concerned, a norm is the only consistent basis for predicting, even where known differences exist. A bench mark or base is still required.

An alternative approach to standard data is to avoid the use of time study entirely and assign times based upon the individual who will perform the operation. However, it is questionable as to whether planners estimate time based on who is to do the job, rather than on what is to be done. Certainly a knowledge of the elements of work to be performed generally forms the basis for predicting completion time by planners.

Concerning the compiling of standard data where time study is used, the first step is to obtain actual average time. This data is then typically rated for performance and sometimes includes allowances, i.e., simplified MTM data.

To summarize, the paper discussed the following:

1. Scheduling requires prior estimates.

2. Standard data is often used as a basis for estimating.

3. Considering the theoretical problems involved, is standard data suitable?

Alan J. Rowe

INSTITUTE INTERESTS

(Continued from page 131)

ence of Dr. Risto Vuori of Valkeakosli, Finland, a Fulbright scholar at N. C. State College.

Mr. Joseph C. Nickels, Assistant Chief Industrial Engineer, Post Office Department, Washington, D. C. was the guest speaker at the February meeting and spoke on "Industrial Engineering Applications in the Post Office Department".

At the March meeting, Mr. S. C. Donnelly, Superintendent of Burlington Shops, Western Electric Company spoke on "Advanced Planning and Scheduling for Production".

Dr. Max A. Woodbury of the Logistics Research Project at George Washington University spoke to the chapter at the April meeting on the subject "Mathematical Procedures in Linear Programming".

UNIVERSITY OF ARKANSAS STUDENT CHAPTER

The University of Arkansas Student Chapter of the AIIE was chartered December 14, 1955. Professor H. G. Thuesen, Head of the School of Industrial Engineering and Management, Oklahoma A & M College, and past national vice-president of the AIIE, was the principal speaker at a Charter Dinner marking the occasion. Over seventy members and guests attended the event, held at the Student Union on the Arkansas campus. Special guests included the presidents of the various departmental societies represented on the campus. The chapter enters the AIIE with a membership of sixty-six.

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